SCIENTIFIC AMERICAN

No. 891 SUPPLEMENT

Copyright by Munn & Co., 1893.

Scientific American Supplement, Vol. XXXV. No. 891. | NEW YORK, JANUARY 28, 1893. | Scientific American Supplement, $5 a year.
Scientific American, established 1845. | | Scientific American and Supplement, $7 a year.

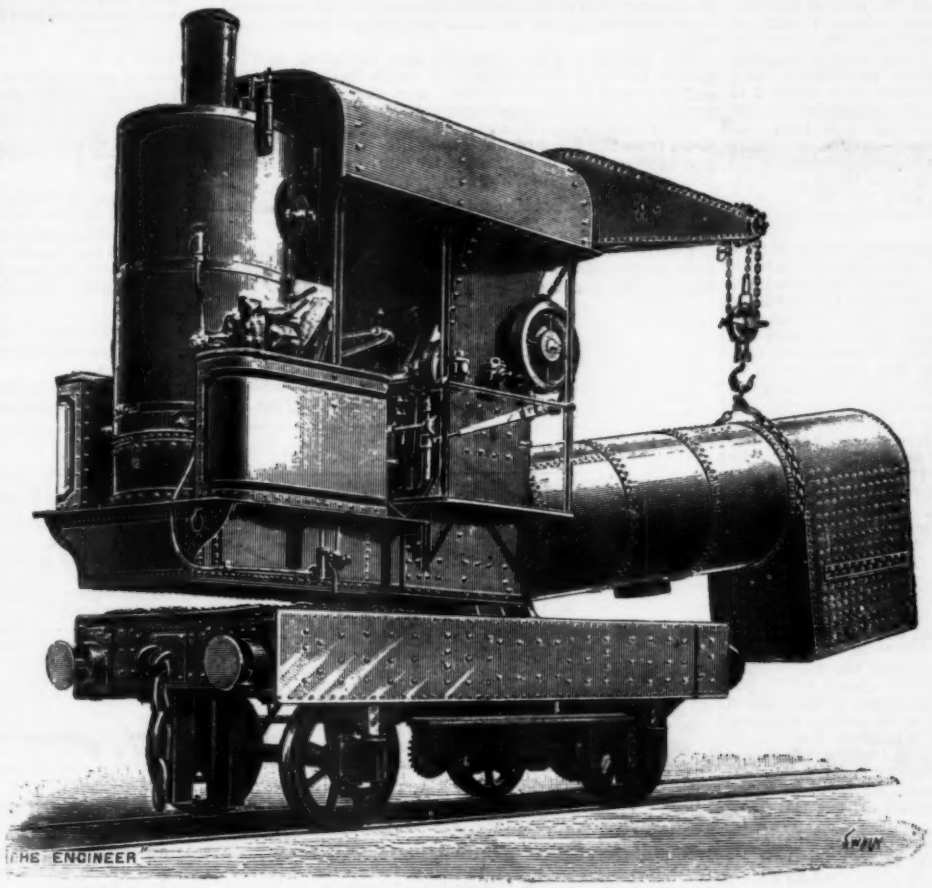
GREAT NORTHERN RAILWAY LOCOMOTIVES.

A RECENT number of the *Engineer*, London, contains a series of excellent illustrations of the yards, shops, tools and machinery of the Great Northern Railway at Doncaster, England. This railway ran its first train from London to York in 1852. The works, at which most of the rolling stock is made, cover an area of some thirty acres. The various shops are provided with the most effective appliances for producing the best work. The pattern machinery, the foundries, lathes, boring machines, cranes, etc., all are first-class. The locomotive engineer of these great works is Mr. Patrick Stirling, now a veteran of 70 years. For over a quarter of a century he has had charge of the works, and has designed most of the locomotives that have been turned out. We give herewith illustrations of a type of the express passenger locomotives built at these works, designed by Mr. Stirling; also of one of the yard traveling cranes. The following are some of the particulars of the express engine:

Express Passenger Engine; Outside Cylinders 18 in. diameter by 28 in. stroke.

Wheels—	
Bogie	3 ft. 10 in. diam.
Driving	8 ft. "
Trailing	4 ft. 6 in. "
Tractive power	94 5 to 1.
Boiler (telescopic)—	
Diameter	4 ft. 2 in. at largest diameter of barrel.
Length of barrel	11 ft. 5 in.
Length of casing	6 ft. 2 in.
Boiler pressure	160 lb. per sq. in.
Heating surface:	
Tubes	936 sq. ft.
Fire box	109 "
Total	1,045 "
Grate area	17¾ sq. ft.
Number of tubes	174, and 1¾ in. dia. (copper).

Weights— Engine:	Tons.	cwt.	qrs.
Bogie	17	11	0
Driving	17	0	0
Trailing	10	12	0
Total	45	3	0
Tender: Total weight in working order, including 3,500 gallons of water and 5 tons of coal	40	5	3
Total weight of engine and tender	85	8	3



YARD TRAVELING CRANE—GREAT NORTHERN RAILWAY.

The fact that locomotives of the unusual design of the latter engines should not only have survived so long, but that they still give the utmost satisfaction, is a strong testimony to the prescience of their designer. They are principally used between London and Grantham, but they may be found working trains all over the line. That portion of the system between London and Grantham is, however, free from heavy inclines and sharp curves. The work demanded from them is comparatively steady though heavy, and they accomplish it in all weathers with great certainty and celerity. The use of a pilot is almost unknown on the Great Northern, and whether the train consists of eight coaches or eighteen the engines have to haul them unaided. They have been specially designed for speed, and it is indisputable that they can travel. Mr. Rous Martin, locomotive engineer, recorded the following speeds while traveling in the 2 P. M. express from Manchester to London, 208 miles, by the Great Northern Railway. The time allowed is 255 minutes, including stops. Allowing fifteen minutes for

EXPRESS PASSENGER LOCOMOTIVE—GREAT NORTHERN RAILWAY.

these, we have an average speed of fifty-two miles an hour for the run:

	h.	m.	sec.		Miles.		Speed. Miles per hour.
Passed Stoke Box.....	4	27	21	P. M.	—		—
" Corby	4	30	30	"	—		—
" Little Bytham...	4	34	15	"	44½	=	75·45
" Essendine.....	4	37	10	"	38½	=	77·10
" Tallington.	4	40	1	"	30½	=	79·40
Distance.....					123½	Average mileage per hour	77·15

We have here, it will be seen, no short spurt of a mile or so, but a continuous run of over twelve miles accomplished at a speed of over seventy-seven miles an hour, a performance which has not, we believe, often been equaled by any other locomotives. But a yet more interesting record is that which will be found in a table giving the daily performance during the time of "the race to the North" of the Scotch express, between London and York, in August, 1888. From this table it appears the run of the 25th of August, from London to Grantham, is particularly worthy of notice, the average speed for the whole 105 miles exceeding 60 miles an hour. The train, which weighed 105 tons, exclusive of the engine, passengers, and luggage, ran the distance in 1¾ hours, and arrived 10 minutes before it was due. The average weight of the six-wheeled Great Northern carriage is 15 tons. In summer the trains consist of sixteen coaches, weighing 240 tons, and in winter of twelve coaches, weighing 180 tons, exclusive of the passengers and their luggage. These figures may be compared with the 143 tons of the crack American trains, with engines burning about twice as much coal per mile.

Our readers will, we think, hardly fail to be struck with the extreme simplicity of the engine. There is really not one superfluous part, and all the parts have been so carefully proportioned to the duty they have to perform, and the stresses to which they are submitted, that breakdowns are almost unknown, and the repair bills are exceedingly small. The engines, too, are exceptionally economical in the consumption of fuel, and it must not be forgotten that they are not provided with any special coal; it is all North country and much of it runs small. This is the more remarkable because it will not escape our readers that the grate area and heating surface are by no means large. The tubes are long, however, and the water spaces are nearly an inch wide, instead of the five-eighths to three-fourths usually met with. Steam is easily kept up with a blast pipe 4¾ in. diameter, and the back pressure is very moderate, and the blast, being soft, does not tear the fire to pieces. The internal friction of the machine is, no doubt, very small. The pistons have a stroke of 28 inches. The tractive effort of the engine is, therefore, the same as that of an engine with 26 in. stroke and 7 ft. 6 in. wheels, or 24 in. stroke and 6 ft. 10½ in. wheels. The large diameter of the wheels reduces the number of reciprocations, the revolutions being 210 per mile and the piston speed 980 ft. per minute at sixty miles an hour. In theory it is an axiom that rapidity of reciprocation in an engine does not represent any loss of power, but in practice it certainly does, and it is fair to assume that the rolling resistance and axle friction of the large wheel must be less than that of the small wheel, and so, as we have said, the internal resistance of these engines cannot fail to be very small.

There are certain peculiarities in the construction of the boiler, some of which we have already incidentally mentioned, such, for example, as the fact that no rollers are used in fixing the tubes, which are simply expanded with a drift, and ferruled at the fire box end. It is found that no leakage takes place. Mr. Stirling does not believe in domes, and the steam is taken by a perforated pipe lying along the top of the steam space. The engines scarcely ever are troubled with priming. The staying is peculiar. No longitudinal through stays are used, diagonal stays, as shown, taking their place. The arrangement of the roof stays has been criticised. At the first glance it would appear that when the fire is first lighted and the fire box plates expand and rise, violent strains must be set up and leakage caused, because of the rigid connection between the inner and outer shells. But in practice nothing of the kind takes place. If it did, Mr. Stirling is not the man to retain a faulty system of construction. In work roof stay leakage is unknown, and at least three years' continuous service can be got out of a fire box before any repairs worth naming are required. Much more might be said about these engines. It will be enough to say here that the tractive effort is 94·5 lb. per pound of average effective cylinder pressure. There are 174 tubes 1¾ in. diameter. The tube surface is 936 square feet; the fire box 109 square feet: total 1,045. The grate area is 17¾ square feet. The pressure 160 lb. The total length is 29 ft. 9 in. over the buffers. The load on the leading bogie wheels is 8 tons 2 cwt.; on the trailing bogie wheels, 9 tons 9 cwt.; on the drivers, 17 tons; and on the trailing wheels, 10 tons 12 cwt.; total weight in running order, 45 tons 3 cwt.

CENTRIFUGAL FORCE AS APPLIED TO REVOLVING MACHINERY.

By G. D. HISCOX.

THE disposition and strength of iron or other material, in regard to the tensional force of revolution, is a most important matter for consideration in the designing of all machinery intended for revolution at high speeds, and is especially important as a speed limiting factor for the fly wheels of steam and other engines, pulleys, grindstones, emery wheels and sectional circular saws.

It has been stated by authors that 80 ft. rim velocity per second was the safe limit for fly wheels, while others claim practical figures all the way up to 170 ft. rim velocity, without alluding to the possibilities of overrating by sectional structure. Granting that the higher velocities may be attained with solid rims of good metal, the case is very different with sectionalized wheels of large dimensions, where the keying or bolting together of the sections involves a loss in strength due to the whole area of metal section. For although bolts may be made of equal strength with the sectional area, there will always be weak points by displacement to accommodate the bolts or dowel keys, that should have the most careful consideration in the factor of safety for the assigned speed. It must always be remembered that the total strength due to the force of revolution must be measured by the weakest point in the wheel rim.

The resistance to deflection from a right line of motion that is offered by a body making one revolution in a minute in a circle of 1 ft. radius was found to be 0·000341 of its own weight, and it thus becomes a prime factor in the computation of centrifugal force in revolving bodies. Since this force increases as the square of the radius and also as the square of the number of revolutions per minute, these components, together with the weight of a sectional square inch of the material, of a length equal to the entire circumference of the rim, become the basis of the formula given by Clark, Molesworth and others; viz.: $0{\cdot}000341\ W\ r\ n^2$ = the total centrifugal force in a revolving body or rim. In the case of fly wheels, W = the weight of 1 square inch of section of the whole rim, and the reduction gives the total centrifugal force for 1 square inch of section; this multiplied by the area of the sectional area of the rim gives the total centrifugal force of the whole rim.

The weight in a cast iron rim may be taken as 0·26 pound for each circumferential cubic inch. r = the radius in feet to center of rim. n^2 = the square of the number of revolutions per minute.

The fundamental formula for centrifugal force is derived from the force of gravity as illustrated in planetary motion and is expressed by the following notation: $\frac{W \times V^2}{g \times r}$ = total centrifugal force of a planetary body; in which W may be the weight in units of force or pounds, V^2 the velocity of the circle of gyration in feet per second, g gravity, or 32·166, and r the radius of the circle of gyration in units of measure or feet; the circle of gyration being the circle of revolution passing through the center of gravity of the revolving body.

For a fly wheel or pulley this may be taken as the center of a section of the rim without material error.

In computing the element of tensional strain in the material composing a revolving ring, as a fly wheel or pulley, it is proper to take into consideration the peripheral equilibrium at the terminal points of any diameter, and to so divide the total centrifugal force that the true strain on the metal at two opposite points in the circumference may be ascertained.

For this purpose let Fig. 1 represent any cylindrical

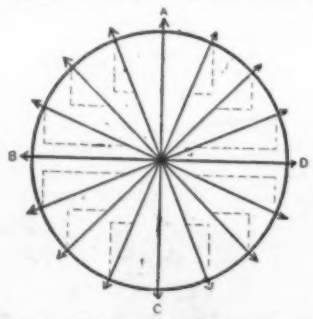


DIAGRAM SHOWING RESOLUTION OF CENTRIFUGAL FORCE.

vessel subjected to internal pressure, as a steam boiler, a cylinder or pipe in which pressure is generated through the means of a fluid or elastic body. It is evident that the force becomes radial and equal to the pressure per square inch on every inch in the circumference and that the total pressure is equal to the gauge pressure multiplied by the number of inches in the circumference, and that this sum represents the total pressure on each longitudinal inch of the cylinder. This corresponds with the radial nature of centrifugal force; both requiring the same solution for obtaining the final strain on the metal forming the resisting element.

Again referring to Fig. 1, the tension on the metal in resisting the internal pressure through any particular section, as B D, is equal to the sum of the radial pressures resolved into the direction at right angles to B D, or parallel to the strain in the metal at any two points, B D, and in the direction of A C.

This by the resolution of forces, as shown by the dotted half parallelograms in the figure, is found to be the same proportion as the circumference bears to the diameter. Hence the total circumferential pressure divided by 3·1416 equals the total pressure at right angles to the diameter B D in the same terms; and as the resistance of the metal is exerted at each end of the diametric line, then to obtain the strain on one side of a cylinder, fly wheel or pulley, a further division by 2 gives the total strain on a unit of metal on one side. In revolving wheels this is usually a section of 1 square inch. In the last formula, by substituting the weight of 1 cubic inch of cast iron (0·26) for W, and multiplying by the radius in inches, we get the actual strain in 1 square inch of the rim. Making S = to the stress per square inch of rim, then $S = \frac{W \times V^2}{g \times r} \times 12\ r$, and reducing, $S = \frac{12 \times W \times V^2}{g}$ and by substituting for W the weight of 1 cubic inch of cast iron, and V^2 = the square of the velocity of rim in feet per second, we have $S = \frac{12 \times 0{\cdot}26 \times V^2}{32{\cdot}166}$ and again reducing to lower terms,

$S = 0{\cdot}097 \times V^2$.

Another and perhaps a more easily worked formula for the actual strain per square inch of section in the rim is derived from the last by using the expression $\left(\frac{D,\ 3{\cdot}1416\ N}{60\ \text{seconds}}\right)^2 \times 0{\cdot}097$ = strain, D being the diameter in feet, N the revolutions per minute. By reducing this to its lowest terms we have $(D \times N)^2 \times 0{\cdot}0002659$ = strain, and with this formula we have computed the actual strain per square inch of section for fly wheels and pulleys of various sizes and speeds.

In the table, the figures at the bottom of each column indicate a reasonable limit of strain due to a factor of safety of six for ordinary solid cast iron fly wheels and pulleys.

STRAINS IN FLY WHEELS AND PULLEYS.

Diameter.	*Actual Strain per Square Inch of section of Fly Wheels and Pulleys with a Safe Factor Limit, at the last Intersection of the Lines of Diameter and Columns of Revolution.* Revolutions per minute.											
ft.	75	100	125	150	175	200	225	250	300	350	400	500
2	5.98	10.63	16.62	23.93	32.57	42.54	53.85	66.48	95.78	130.30	170.19	265.92
4	23.93	42.54	66.48	95.73	130.30	170.19	215.40	265.92	382.92	521.22	684.76	1063.70
6	53.84	95.73	149.58	215.37	293.19	382.86	484.65	598.33	861.57	1172.76	1531.71	2393.32
8	95.72	170.19	265.92	382.80	521.22	680.78	861.66	1063.70	1531.68	2084.90	2739.04	.....
10	149.56	265.92	415.50	598.27	814.41	1063.72	1346.28	1662.03	2393.32	.....	.....	.....
12	215.38	382.92	598.33	861.51	1172.75	1531.76	1938.60	2393.32	.....	.....	.....	.....
14	293.15	521.21	814.39	1172.61	1596.25	2084.90	2638.71	.....	.....	.....	.....	.....
16	382.89	684.76	1063.70	1531.58	2084.90	2723.13	.....	.....	.....	.....	.....	.....
18	484.60	861.59	1346.24	1938.41	2638.71	.....	.....	.....	.....	.....	.....	.....
20	598.27	1063.70	1662.03	2393.32	.....	.....	.....	.....	.....	.....	.....	.....
22	723.91	1287.07	2011.05	2895.65	.....	.....	.....	.....	.....	.....	.....	.....
24	861.52	1531.68	2393.32	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	1011.08	1797.65	2808.83	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	1172.61	2084.85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	1346.12	2393.11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
32	1531.58	2739.04	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

For obtaining the total strain between any two segments of a sectionalized fly wheel or pulley, multiply the amount in the table at the intersection of the columns of speed with the lines of diameter by the area of the rim in square inches, which gives the total strain that must be provided for by the bolts, dowels or links that fasten the rim together; not forgetting that any mortises or recesses for bolts or key should be allowed for in the factor of safety by making a proper proportion between the asigned limit of velocity for a full strength rim and the reduced strength due to sectionalizing.

This point is a most vital one in the designing of large segmental fly wheels, and suggests an axiom, that the rim fastenings in a sectionalized fly wheel or large pulley should of necessity be made as near to the total strength of the mass in the rim as possible; not necessarily for the assigned speed alone, but for the possibilities of runaway accidents.

The arms of fly wheels should not only have a symmetrical form of stability, suitable to the size and weight of their rims, but should also have a form for strength near the hub with a liberal factor of safety, to meet the thrust of the piston at the point of its greatest pressure upon the arms.

The stress at this moment becomes greatest in large belt fly wheels when transmitting the whole power of the engine at their periphery. In such the whole strain of transmission is thrown upon the arms with all the force of the piston pressure, varying from 0 to an amount equal in some cases to the initial gross piston pressure with a late cut off.

The gyratory action of a fly wheel, or the disposition of the crank thrust to produce a wabbling motion of the rim, and the resistance to such action by the stability in the plane of motion of the mass of the rim, is perhaps of little moment in a new engine, in which the boxes are well adjusted and perfect in form, but is a growing source of mistrust and danger from the wear and neglect of the main journal boxes to the extent that the thrust of the piston causes a lateral movement of the shaft at the crank end in the direction of thrust and in the opposite direction in the off bearing for each stroke.

This movement, however small, must be taken up in the spring of the arms, or the whole rim must assume a wabbling motion. This induces a disintegrating action leading to dangerous conditions, according to the extent of the movement. The remedy with the designer is in adjustable sectional journal boxes, and with the engineer watchfulness and a sense of responsibility in keeping the running parts of an engine up to its normal condition.

GRINDSTONES,

when of large dimensions and running at high speeds, are a constant source of apprehension, and have too frequently been destructive to life and property by fol-

lowing the course of nature when overtaxed. Apart from the speed of grindstones as a cause of bursting, probably the majority of accidents have really been caused by wedging them on the shaft and over-wedging to true them. The holes being square, the excessive driving of wedges to true the stone starts cracks in the corners that eventually run out until the centrifugal strain becomes greater than the tenacity of the remaining solid stone, when a leap for liberty is the result. Hence the necessity of great caution in the use of wedges, as well as the holding of large quick-running stones between large flanges and leather washers. For the computation of the centrifugal force of a grindstone, the formula may be the same as for fly wheels, by only inserting the weight of the stone per cubic inch in place of the cast iron, and the radius of the center of gyration in place of the radius of the periphery. For the centrifugal strain tending to break asunder a disk of grindstone, the mean weight of which is 0·078 pound per cubic inch (135 pounds per cubic foot), with a radius of gyration equal to 0·7071 of the radius of the periphery, and using the value of the radius (r) in inches in the formula for strain, as before stated, we have strain $= \frac{W \times V^2}{g \times r} \times 12\ r$, and reduced, $S = \frac{12 \text{ inches} \times W \times V^2}{g}$. By substituting for W the weight of a cubic inch of grindstone (0·078) and for V^2 the square of the velocity of the circle of gyration in feet per second, we have $\frac{12 \text{ inches} \times 0{\cdot}078 \times V^2}{32{,}166}$ and by reducing $S = 0{\cdot}029\ V^2$. By simplifying the terms as in the formula for fly wheels, and by substituting the value of D in terms of the circle of gyration, which is 0·7071 D, we derive from the above expression $\frac{(D\ 3{\cdot}1416\ N)^2}{60 \text{ seconds}} \times 0{\cdot}029$ and by further reduction $(0{\cdot}7071\ D \times N)^2 \times 0{\cdot}0000795$ = the stress per square inch of section of the stone.

For example, a grindstone 4 ft. in diameter, making 200 revolutions per minute, 4 ft. × 0·7071 = 2·8284 ft. diameter of the circle of gyration. Then 2·8284 × 200 = 585·68, and $585{\cdot}68^2 = 343021 \times 0{\cdot}0000795 = 27{\cdot}27$ or say 27¼ pounds per square inch strain to pull the stone apart. As the sandstone has a tensile strength of from 250 to 350 pounds per square inch, the factor of safety is an average of about ten. This is too small for sandstones that vary in tensile strength from 175 to 225 pounds per square inch. Such a stone should not be trusted at more than 160 revolutions per minute for 4 ft. in diameter or 2,000 ft. peripheral velocity per minute. With this formula we tabulate the speed and strain per square inch of area of cross section; the variation in thickness not materially affecting the result, as every inch in width bears its own strain. The Ohio stones are somewhat denser than the figure above given, weighing about 0·081 pound per cubic inch, while the Huron stone is still more dense, 0·089 pound per cubic inch, but both have a greater tensile strength in proportion to their density. The Ohio stone will bear a speed of 2,500 to 3,000 ft. per minute, which latter should never be exceeded. The Huron stone is still stronger and can be trusted up to 4,000 ft. peripheral velocity, when properly clamped between flanges and not excessively wedged in setting.

STRAINS IN GRINDSTONES.

Limit of Velocity in Revolutions per Minute and Approximate Actual Strain per Square Inch of Sectional Area for Grindstones of Medium Tensile Strength for the Sizes in First Column.

Diameter.	Revolutions per minute.						
	100	150	200	250	300	350	400
Feet	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
2	1·58	3·57	6·35	9·93	14·30	18·36	25·42
2½	2·47	5·57	9·88	15·49	22·29	28·64	39·75
3	3·57	8·04	14·28	22·34	32·16		
3½	4·86	10·93	19·44	30·38			
4	6·35	14·30	27·37				
4½	8·04	18·08	32·16				
5	9·93	22·34					
6	14·30	32·17					
7	19·44						

Approximate breaking strain ten times the strain for size opposite the bottom figure in each column.

The figures at the bottom of columns designate the limit of velocity (in revolutions per minute) at the head of the columns for stones of the diameter in the first column opposite the designating figure.

A general rule of safety for any size grindstone that has a compact and strong grain is to limit the peripheral velocity to 47 ft. per second.

EMERY WHEELS.

The emery wheel is eminently a speed wheel for grinding; its ultimate tensile strength may be given at 1,000 pounds per square inch, although the wheels of different makers and for different purposes vary considerably above and below this figure. The different degrees of hardness of the wheels of any maker will also vary the tensile strength and weight. The lightest wheels are about 0·087 pound to a cubic inch, the heavy ones a little over ⅛ pound per cubic inch. The light wheels give less centrifugal force; therefore, the use of ⅛ pound in the formula is a safe figure, and using 1,000 pounds as the breaking strength, we have computed the table of strains on the basis of a safe factor of about eight at maximum speed for best wheels. Using the same formula as for grindstones and substituting the weight of the emery wheel, 0·1 pound per cubic inch, we have from the fundamental formula the value $\frac{12 \text{ inches} \times 0{\cdot}1 \times V^2}{32{,}166}$ and by reducing as before $S = 0{\cdot}0373\ V^2$. Again substituting the equivalent terms, as in the previous formula, we have $\left(\frac{D\ 3{\cdot}1416\ N}{60 \text{ seconds}}\right)^2 \times 0{\cdot}0373$, and again reducing and interpolating the ratio of the circle of gyration (0·7071), we have $(0{\cdot}7071\ D \times N)^2 \times 0{\cdot}00010226$ = the stress per square inch of a section of an emery wheel.

STRAINS IN EMERY WHEELS.

Diameter. Inches.	*Actual Strain Per Square Inch of Section in Emery Wheels at the Velocities at Head of Columns for Sizes in First Column.* Revolutions per minute.												
	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3,000
4	.....	.....	.....	.....	.....	.....	.....	22.67	27.43	32.64	38.31	44.43	51.12
6	.....	.....	.....	.....	.....	.....	.....	51.13	61.86	73.62	86.40	100.21	115.03
8	.....	.....	22.67	32.65	44.45	58.05	73.47	90.71	109.76	130.62	153.30	177.80	.....
10	.....	.....	35.47	51.08	69.51	90.81	114.94	141.90	171.71	.....	.....	.....	.....
12	18.40	32.72	51.12	73.62	100.21	130.88	165.65	.....	.....	.....	.....	.....	.....
14	24.80	43.90	68.70	99.21	134.65	175 60	.....	.....	.....	.....	.....	.....	.....
16	32.57	57.65	90.24	130.31	177.80	.....	.....	.....	.....	.....	.....	.....	.....
18	41.41	73.62	115.03	165.65	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	50.98	90.23	141.22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
22	61.81	109.41	171.23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
24	73.62	130 88	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	86.36	152.85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	115.04	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
36	165.64	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

With this formula we have computed the stress per square inch for emery wheels of commercial sizes, terminating at the maximum speed with a factor of safety of about one-eighth of the breaking strain for wheels of over 1,000 pounds tensile strength.

There is a large variation in the listed speeds of emery wheels by different makers—4,000 as a minimum and 5,600 maximum feet per minute, while others claim a maximum speed of 10,000 feet per minute as the safe speed of their best emery wheels. Rim wheels and iron center wheels are specialties that require the makers' guarantee and assignment of speed.

In any body revolving upon a central axis, as a globe, disk or ring, there is a circle within the periphery in which all the force of revolution of the whole body may be said to make an average center or circle that represents the concentrated force of the revolving mass. This is the circle of gyration. In bodies revolving around an axis external to their mass the center of force is designated as the center of gyration of the body. This center of gyration, therefore, represents the moment of inertia for all the particles of the revolving mass.

The distance from the axis to the center or circle of gyration is the radius of gyration, and is one of the essential elements in the computation of centrifugal force. For a solid sphere of uniform density revolving around its diameter as an axis, the radius of gyration $= \sqrt{\frac{\text{radius of the sphere}^2}{2{\cdot}5}} = 0{\cdot}63246$ of the radius of the sphere; and for a uniform disk = the radius of the periphery × $\sqrt{\frac{1}{2}} = \frac{1}{1{\cdot}4142} = 0{\cdot}7071$ of the radius of the periphery.

For a ring or disk with an open center the radius of gyration $= \sqrt{\frac{\text{inner radius}^2 + \text{outer radius}^2}{2}}$

The last expression is used in the formula for the power of

CENTRIFUGAL PUMPS.

The centrifugal force of a fluid when it becomes a revolving body is well illustrated in the action and power of this class of pumps; which by the mere forced revolution of a ring of water causes its translation and successive renewals with a lifting power to move large volumes of water, silt and sand with a clear run that defies the action of reciprocating pumps with valves and rubbing surfaces that would be soon destroyed by the material that will have a clean run through a centrifugal pump.

The elements of computation involve the weight of the material to be lifted; the velocity of the circle of gyration, its radial distance and gravity.

The weight of a disk of water in a centrifugal pump with wings 12 inches in diameter and with 4 inches of the central part neutral from the absence of wings and the entrance of the suction pipe, with an average thickness of 1 inch, is equal to $12^2 \times 0{\cdot}7854 = 113$ cubic inches for the disk, less $4^2 \times 0{\cdot}7854 = 12{\cdot}56$ for the neutral center = 100·44 cubic inches × 0·03615 pound, the weight of a cubic inch of water = 3·63 pounds, the weight of the disk of water with a forced revolution.

Then by the formula for centrifugal force $\frac{W \times V^2}{g \times r}$ in which W = weight in pounds, V^2 = square of the velocity of the circle of gyration in feet per second, g = the force of gravity, 32,166, and r the radius of gyration in feet, we have for example, with the above size and weight at 1,000 revolutions per minute, the radius of gyration $= \frac{\sqrt{2^2 + 6^2}}{2} = \frac{\sqrt{40}}{2} = 4{\cdot}472$ inches. For the velocity of the circle of gyration $\frac{4{\cdot}472 \times 2 \times 3{\cdot}1416 \times 1000}{12} = \frac{2341{\cdot}015}{60 \text{ seconds}} = 39$ feet per second. The radius of gyration must be taken in feet, which $= \frac{4{\cdot}472}{12} = 0{\cdot}3726$.

The equation becomes $\frac{3{\cdot}63 \text{ lb.} \times 39^2}{32{\cdot}166 \times 0{\cdot}3726} = \frac{5521{\cdot}23}{11{\cdot}985} =$ 460·67 pounds, the total centrifugal force.

As this represents the force of the whole area of the circumference of the circle of gyration 1 inch wide, its division by the number of inches in the circumference will give the force or pressure per square inch; therefore $\frac{460{\cdot}67}{8{\cdot}942 \times 3{\cdot}1416} = 16{\cdot}4$ pounds per square inch pressure, and $16{\cdot}4 \times 2{\cdot}3 = 37{\cdot}72$ feet, the static height of water due to the centrifugal force of the pump.

The loss by clearance between the arms and shell, together with the friction of the water on arms, shell, pipe and bends, as also for the requirement for velocity of flow, lessens the height for effective flow to the amount of about 20 per cent., according to the perfection of design and construction, leaving from the above static height only about 30 feet as the limit of efficiency of the pump at the speed of 1,000 revolutions per minute.

The quantity of water that would be delivered at the periphery of the wings of the pump if placed at the level of the water of influx and without obstruction will be equal to the static pressure due to its centrifugal force, less the clearance and friction of the pump arms and shell.

Estimating that this will bring the static head to 35 feet, and using the usual formula for discharge: $c\ b\ d\ \sqrt{2g\ h}$ = the volume in cubic feet per second, c = coefficient, 0·62; area of circle of gyration $= \frac{28{\cdot}092}{144} =$ 0·195 square foot, and the square root of twice gravity $\times \sqrt{35} = 47{\cdot}75$. Then $0{\cdot}62 \times 0{\cdot}195 \times 47{\cdot}75 = 5{\cdot}772$ cubic feet per second, less 20 per cent., or 2,078 gallons per minute. As the discharge is nearly in the inverse ratio of the height, and with 35 feet as the limit and 30 feet as the assumed height of discharge, then the difference between 30 and 35 becomes the static head and the basis for computing the discharge of the pump at 30 feet height. This gives by the formula above stated 981 gallons per minute, from which 20 per cent. should be deducted for clearance and arm friction and an additional deduction of 25 per cent. for the friction of the shell, bends, pipe and foot valve, bringing the actual discharge to about 590 gallons per minute.

CENTRIFUGAL FORCE OF BLOWERS.

The power of a blower is due to the weight of air and the velocity of rotation, and, like other revolving bodies, is a matter of computation from the known elements.

Air at mean temperature of 60° has a volume of 13 cubic feet to 1 pound, and $\frac{1}{13} = 0{\cdot}07696$ pound per cubic foot, and on this value is based the computation for centrifugal force of air and the power of blowers. Following a similar formula as for centrifugal pumps, we assume a case which will fully illustrate the formula and its principles.

A conoidal incased fan of the form of which Fig. 1 is

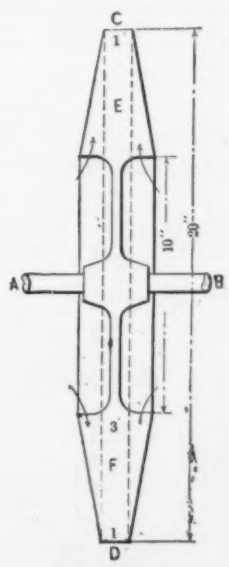


FIG. 1.

a section in one of the types of high pressure single blowers, having an outside diameter of 20 inches, inside diameter of disk 10 inches, 1 inch opening at the

circumference and 3 inch opening at the inner edge of disk.

Area of periphery = 1 inch × 20 inches × 3·1416 = 62·832 inches. Area of equivalent in space, 2 inches × 10 inches × 3·1416 = 62·832 inches. Volume of disk, 62·832 inches × 5 inches = 314·16 cubic inches; although inner space is made wider to lessen friction.

$$\frac{1 \text{ pound}}{13\ c^1} = 0{\cdot}07696 \text{ pound per cubic foot of air.}$$

$$\frac{0{\cdot}07696 \times 314{\cdot}16}{1728} = 0{\cdot}01399 \text{ pound, the weight of the}$$

air in the disk available for centrifugal force. The circle of gyration is found in the same way as before stated for pumps, viz:

$$\sqrt{\frac{10^2 + 20^2}{2}} = 15{\cdot}8113 \text{ inches, and } \frac{15{\cdot}8113}{2} \text{ inches} =$$

$$\frac{7{\cdot}9056 \text{ inches}}{12} = 0{\cdot}6588 \text{ foot, the radius of gyration in}$$

feet. Then, the velocity of the circle of gyration in feet per second, assuming the blower to make 2,000 revolutions per minute, will be

$$\frac{15{\cdot}8113 \text{ inches} \times 3{\cdot}1416 \times 2{,}000}{12 \times 60} = 138 \text{ feet per second.}$$

Then, using the formula for centrifugal force as before stated, $\frac{0{\cdot}01399 \times 138^2}{32{\cdot}166 \times 0{\cdot}6588} = 12{\cdot}57$ pounds, the total centrifugal force. Then, as the opening in this disk is 1 inch wide, and 20 inches × 3·1416 = 62·832 inches in circumference, the area = 62·832 inches, and

$$\frac{12{\cdot}57 \text{ pounds}}{62{\cdot}832} = 0{\cdot}2 \text{ pound per square inch pressure of}$$

the blower, or 3·2 ounces = 0·46 foot water pressure. The volume of air flowing through the blower under this pressure is very much less than through a free opening, the friction of arms, wings, case and pipe obstructing the theoretical flow, which may be computed from the formula $c\sqrt{2g\ h}$, in which c is a coefficient of efflux equal to 0·7, $2g$ = twice gravity, and h = the height in feet of a column of air sustained by the pressure of the fan per square foot.

The pressure being 0·2 lb. per square inch, then 0·2 × 144 = 28·8 pounds per square foot, and $\frac{28{\cdot}8}{0{\cdot}07696} = 374{\cdot}22$ feet air height, 0·07696 being the weight of 1 cubic foot of air, as before stated. Then the equation becomes

$0{\cdot}7\sqrt{64{\cdot}33 \times 374{\cdot}22} = 109{\cdot}438$ feet per second, the velocity of air issuing under 0·2 pound pressure per square inch without friction. Thus having the area and velocity in feet per second, we have 109·438 × 60 = 6566 feet per minute, and $\frac{6566 \times 62{\cdot}8 \text{ inches}}{144 \text{ inches}} =$ 2,863 cubic feet per minute, from which a large allowance must be made for friction and obstruction by the arms, wings and case. Where such a blower is used for forge fires, the area of the nozzles under the pressure, less the friction, governs the quantity of air delivered to the forges.

VIBRATING POWER OF UNBALANCED ELEMENTS OF REVOLUTION.

It is a conceded maxim that a body, whether in the form of a wheel or continuous rim, or an arm carrying weights at its ends—whether symmetrical in distance from the center or not—if all its parts are in exact proportion in weight to their distance from the center of revolution and from the plane of revolution, they are balanced at rest, and at all speeds.

A mechanically absolute center and an absolute plane of rotation, to which every particle of a revolving body is adjusted, are as necessary to smoothness of motion in mechanics as with planetary bodies. The plane of rotation and the axis must be at right angles, and with perfect balance the highest speed may be attained.

Any deviation from this axiom involves a vibratory or unbalanced motion which when restrained by journal boxes tends to set up counter motions in the surrounding material.

Illustrating this point, Fig. 2 represents the condi-

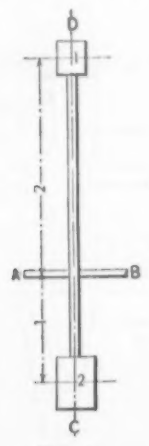


FIG. 2.

tions of stability of revolution with balanced elements, in which the weight, 2, at the distance, 1, is found to exactly balance the weight 1 at the distance 2, the dotted line, C D, being the plane of revolution, exactly at right angles to the axis, A B, and in which the center of gravity of each weight coincides with the plane of revolution. Such an arm and weights will be perfectly balanced on its axis at rest and under all speeds of revolution upon its axis.

Any variation from this relation, as shown in Fig. 3, produces two planes of revolution in which each re-

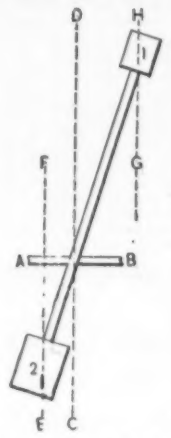


FIG. 3.

volving body has no counterpart in its plane of revolution and, therefore, produces a strain to draw the axis, A B, out of its normal position with all the centrifugal force due to the revolving bodies, at their relative axial distances, 1 and 2, multiplied by the sine of the angle of deviation from the axial plane, C D. This is well illustrated by the action of suspended centrifugal driers, in which the wabbling action of the shaft is well shown from the inability to exactly balance the load in the plane of revolution. With centrifugal driers having their bearings in fixed boxes the vibration from unbalanced revolution becomes excessive and will set a whole building in a tremor.

To illustrate the power of an unbalanced wheel or any revolving body, referring again to Fig. 2, assuming the weight at D overbalanced by ½ pound and the distance of its center of gravity 2 feet from the axis, and revolving at 1,000 revolutions per minute, the total unbalanced centrifugal force amounts to 679 pounds, moving around the center 16 times per second.

The magnifying of the power of vibration of small unbalanced bodies under great velocity by revolution is a source of apprehension and danger by its effect in setting up vibration in floors and buildings. When the vibrations thus set up become in unison or synchronal, the effect becomes so intensified, even by the smallest unbalanced forces, as to not only annoy persons, but to endanger whole buildings. The synchronal unison of vibration does not require that the revolving unbalanced body shall revolve in the same time as the vibration of a floor or a building. It belongs to the system of musical harmonies, and, so long as the vibrations are even divisions, the harmony is more or less perfect and the synchronism will be sustained, while, on the other hand, if the relative ratios of vibration are fractional numbers, the vibrations will cease or become so broken as to become harmless. Instances are known in proof of the unison between rotating unbalanced and reciprocating machines with the building in which they were located, that it became necessary to maintain a certain speed in order to keep the building and floors from violent vibration. There are some remarkable instances of this in the motion of printing presses, in which a slight variation of speed will greatly increase or decrease the vibration of buildings. An interesting trial of an emery wheel but slightly unbalanced by wear has shown its synchronal power of setting up vibrations on a floor at a number of different speeds, when at some intermediate speed the vibrations would nearly cease. The balancing of cutter heads for planing machines becomes an important point in their manufacture, requiring uniformity in the density of the main casting, perfect symmetry in all its parts, as well as uniformity in the weight and position of the knives, for it is this perfection of make and balance that makes a smooth surface when at work. No matter how well it is balanced on the straight edges, if not balanced on the plane of rotation, it will make the journals vibrate and the planed surface wavy.

The balancing of millstones is one of the fine arts in the millstone process of making flour. The requirement in this case is that the plane of revolution shall be parallel with the face of the stone, and also be coincident with the spindle bearing in the yoke. The variable specific gravity of the materials from which the stone is built up makes the balancing a somewhat difficult operation. To be balanced at rest and at various speeds is the basis of perfection in a millstone as well as all revolving machinery.

The cutting away at the top of the stone opposite to the part of the face that runs low and loading with plugs of lead on the same side, below the plane of revolution, is the usual method of balancing millstones.

The question has often been asked by experimenters and mill operators, how fast a disk of iron or steel, a circular saw for instance, can run with safety, and at what speed disks of metal will burst. By using the formula as before stated in article on "Centrifugal Force" in this journal April 7, and substituting the square of the tensile strength of any metal and its weight per cubic inch, for the terms V^2 and W, the number of revolutions at which it may break can be obtained. Then the equation will become

$$\frac{12 \times W \times \text{tensile strength}^2}{32{\cdot}166} = \text{the square of the velo-}$$

city of the circle of gyration in feet per second.

Its application to the case of a steel disk 3 feet in diameter and having a breaking tensile strength of 90,000 pounds per square inch may be readily computed.

The weight of good saw plate is approximately 0·283 pound per cubic inch. Then $12 \times 0{\cdot}283 \times 90{,}000^2 = 855{,}176$, the square of the velocity, and $\sqrt{855{,}176} = 924{\cdot}8$ feet, the velocity of the circle of gyration per second.

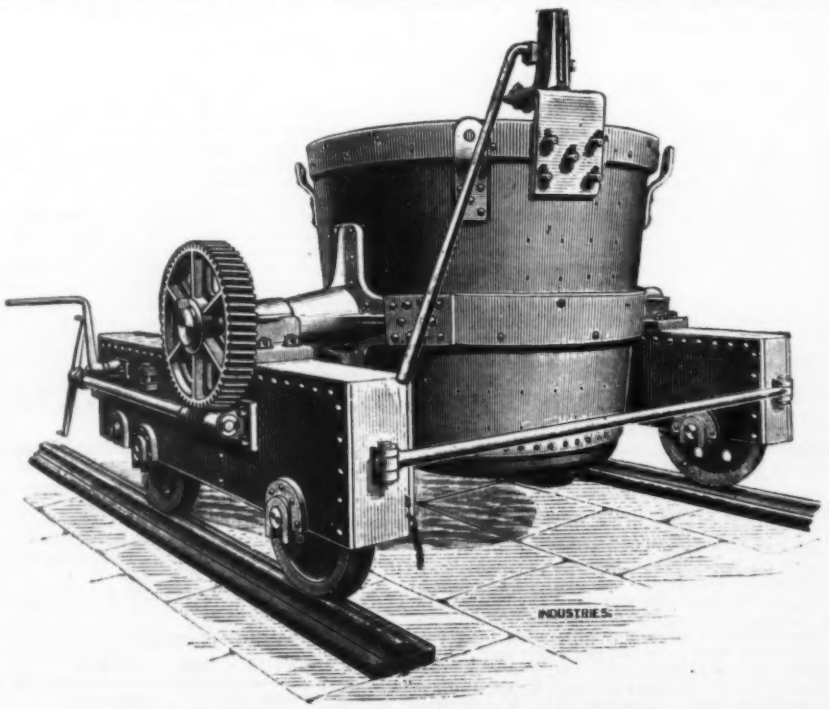
As the diameter 3 feet × 0·7071 = 2·1213 × 3·1416 = 6·664 feet = the circumference of the circle of gyration; then $\frac{924{\cdot}8}{6{\cdot}664} = 138{\cdot}7$ revolutions per second, or 8,322 revolutions per minute, to burst the disk.

As the relation of bursting speed is as the squares of the diameters with steel of a uniform tensile strength, the bursting speed of an 18 inch steel disk would be four times greater than the 3 foot disk, or 4 × 8,322 = 33,288 revolutions per minute, while a 1 foot disk would require 9 × 8,322 = 74,898 revolutions per minute to burst it.—*Iron Age.*

IMPROVED STEEL CASTING LADLE.

THE steel ladle and carriage shown in the engraving below is one of the latest type manufactured by Messrs. Friedenthal & Co., Ltd., Preston, examples of which are at work in several large Siemens steel works, and are giving general satisfaction. This design is used for all sizes from 10 tons to 40 tons capacity, the one illustrated having a capacity of 18 tons. The ladle is built of ⅜ in. steel plates welded at the vertical joints, and has a flanged bottom plate riveted inside the shell.

Both shell and bottom are perforated with ⅝ in.



IMPROVED STEEL CASTING LADLE.

holes for the better adhesion and ventilation of the ganister lining.

The tapping gear is of a very simple construction, arranged so as to give a direct lift. It consists of the usual "stopper rod," protected by fireclay sleeves,

cottered into a wrought iron guide bar of large diameter, which is guided in a vertical direction by the cast iron bracket fixed on a plate bracket riveted to the top of the ladle shell. In the ladle shown this plate bracket is fixed to the shell by means of cotter bolts, to facilitate the removal of the stopper gear in order to turn the ladle over when on level ground.

The vertical guide bar is actuated by a lever working through a slot in the guide bar, and connected at the end with the socketed hand lever, the whole forming a very simple and effective contrivance. The nozzle box is of cast iron and of the hinged type arranged so that the fireclay nozzle can easily and quickly be removed and replaced by a new one. The ladle is supplied with four steel plate lifting "ears," capable of sustaining it when loaded to its full capacity. Cast steel trunnions of ample strength accurately turned to suit their bearings on the carriage frame are riveted direct to the ladle shell, which is strengthened round the middle by a strong riveted steel belt.—*Industries.*

LARGE STEAM CYLINDERS AND THEIR LINERS.

ALMOST all large steam cylinders are now built with inner linings or "working liners," as they are called, which if seriously injured or reduced to a dangerous thinness by successive borings, can be removed and replaced by others without the excessive cost which would be entailed by the renewal of the cylinder itself. This applies most particularly to the cylinders of marine engines, where, by reason of the varying angles at which the machinery operates, consequent upon the rolling of the ship, a perfectly even or uniform wear of the bore of the cylinder is never obtained, and a reboring becomes a not infrequent necessity.

Apart, however, from the economy of this arrangement, as indicated above, there are other very important advantages secured by it. In the first place, it renders the moulding of the cylinder very much simpler, and consequently adds enormously to the probabilities of obtaining good castings. It must be remembered that a single cylinder of say 100 in. in diameter is not only a mammoth and intricate casting, with its valve chests, ports, and bosses, but is also a very expensive one to make, requiring not only many weeks for the construction of the pattern, but something like two months to make the mould in the foundry and get it ready to receive the metal. As this is so, it is easy to realize to what a degree of importance all simplifying features rise, and how a 35,000 lb. casting can be utterly ruined by having its design such as to bring over-severe shrinkage strains upon it as the metal cools, cracking the walls or distorting the shape to a useless article. To follow this statement so as to see clearly how much more complicated would be the production of one of these cylinders without the use of the liner, it will be necessary to know that the spaces marked "jacket spaces" in the drawing Fig. 1 are not merely incident to the liner, but are requisite to the cylinder, and would have to be preserved in the single casting. Hence in the moulding these annular intervals would have to be represented by cores of such slight thickness and considerable length as to be most difficult to keep properly in place and to remove after the casting, nor could any slight shifting of these cores be positively detected by inspection, until probably when in boring out the cylinder the tool would cut into the hollow and prove the ruining defect.

Again, a feature of moment is that the liner, being subject to the rapidly changing temperatures of live steam and exhaust, can expand and contract in its length without distress to the main barrel, and to this point of allowance for expansion much attention has been directed in designing the forms of the liners and their connection to the cylinders. A tight joint must be made between the liner and the cylinder to keep steam from passing from the latter to the jacket, and yet this joint must be a "slip" joint.

Fig. 1 represents probably one of the most common forms of the modern liners. Here the cylinder is bored out on the bearing faces, *a a*, and the outer similar faces of the liner turned to the same diameter; then the liner is lightly forced into its place and the bottom flange bolted to the bottom of the cylinder, steam tight. Around the top the "slip joint" is made tight by means of suitable packing and a follower bolted to the liner.

Fig. 2 represents another method of attaching the liner, in which it is bolted to the cylinder at the top circumference, and the expansion joint made at the bottom by fitting a flat copper ring, *x*, over the junction of the liner and cylinder, bolting this ring securely to each. The flexibility of the copper permits of slight changes in length of the liner, and keeps the joint steam tight.

Fig. 3 is still another arrangement, where the tightness of the bottom joint is secured by having the liner fit at that point like a water-grooved piston. This is one of the simplest forms and probably the least expensive, as well as quite efficient if primarily well fitted.

Fig. 4 represents a patented device of one of the leading American designers, and is used without liners on land engines, where the wear of the cylinder is very uniform. The opening, K, permits of easy coring, and the U-shaped ring of heavy copper, P, is finally bolted over this and permits expansion without impairing the steam tightness of the joint. This is not a cheap arrangement, but is a most excellent and efficient one for the purpose intended. It does not, however belong to such cylinders as we are considering, and is only given as an illustration of these expansion joints.

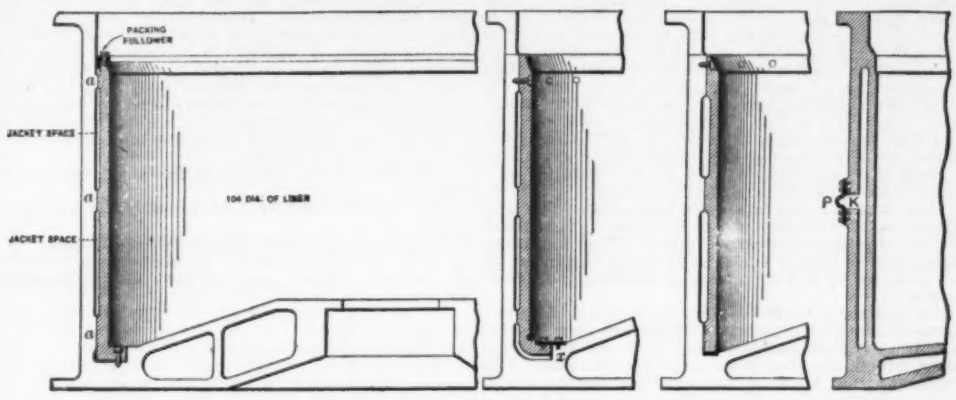


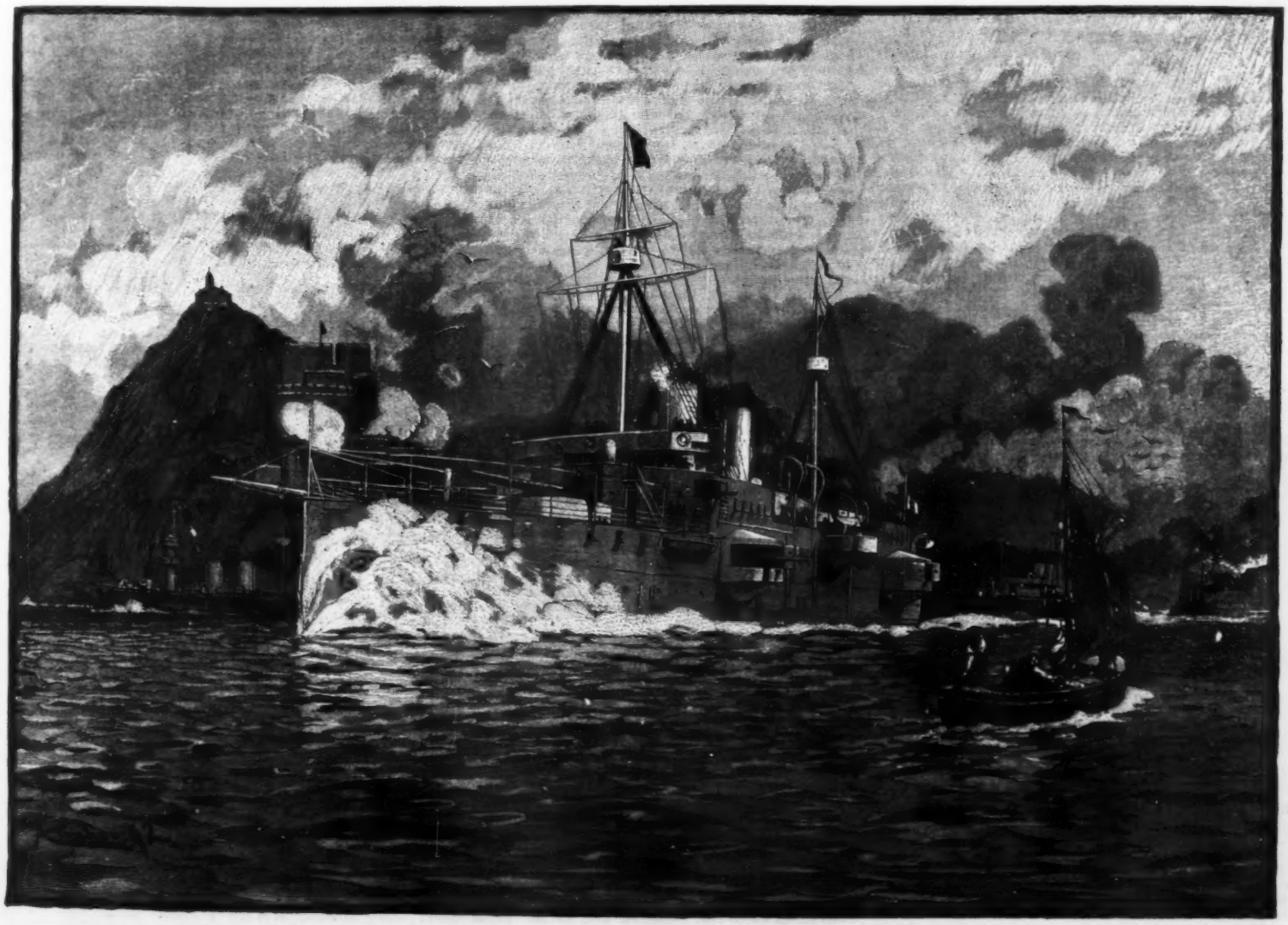
Fig. 1. *Fig. 2.* *Fig. 3.* *Fig. 4.*

LARGE STEAM CYLINDERS AND THEIR LINERS.

Cast iron of very close grain, and as hard as can be well worked with boring tools, is the material deemed most suitable for steam cylinders of large dimensions, as well as for the liners. The high grade of intelligence and skill now directing the operations of our large foundries makes the loss of a casting a rare occurrence, and is a source of very great pride to engineers of the United States.—*Iron Age.*

THE AUSTRIAN RAM-CRUISER KAISERIN ELISABETH.

IN accordance with the plans for a fleet laid out by Admiral Freiherr von Sterneck, in 1884, the Austro-Hungarian monarchy has lately been enriched by the fourth great war vessel, Kaiserin Elisabeth. The new vessel was constructed at the works in Pola under the direction of Chief Engineer Franz Freiherr Juptner von Jehnstreff, from native material. The machinery, which is of the latest pattern, was the work of the "Stabilimento tecnico Triertino," shipbuilders and



THE AUSTRIAN RAM-CRUISER KAISERIN ELISABETH.

engine makers of San Rocco, near Trieste. The designs were made by Eduard Mellier, director of machine construction.

The ship is built according to the newest double bottom system, and is divided into more than one hundred water tight compartments. The powerful steam pumps are capable of pumping out 1,300 tons of water in an hour, thus greatly diminishing the danger of sinking.

The arch armored deck, which is 4 ft. below the water line, closes the lower part of the vessel hermetically and protects the machinery, magazines, etc., from heavy shot. A strong belt of cellulose is fastened to this deck at the sides of the ship, to prevent inflow of water through openings caused by the shots of an enemy. The vessel is built entirely of steel. Its chief dimensions are: Length over all, 341 ft., and 321 ft. between perpendiculars; greatest breath, 49 ft.; draught, 19 ft. 6 in.; and it has a displacement of 4,060 tons. The twin screws, each of which is 14 ft. 3 in. in diameter, are driven by two horizontal, triple expansion engines, that can develop 9,800 H. P., working at a speed of 130 revolutions per minute; that is, 2·4 H. P. per ton, a power that has never been attained by any other vessel of this class except the Kaiser Franz Josef. The speed is 19-20 miles per hour. (The engraving gives a correct idea of the mass of water displaced by the bow, for it is taken from a drawing made from nature.)

The cool water for the condensers is supplied by two powerful centrifugal pumps. There are four double cylindrical boilers, each provided with six arched fire boxes, which, together, open into 2,664 fire tubes. The boilers are fed by four two-cylinder double action pumps. Besides these boilers there is a special cylindrical high pressure boiler for operating the electric lighting plant, the hydraulic pumps for the artillery service, the deck pumps, fire apparatus, ventilators, the capstan, etc. The ship can carry 670 tons of coal, which will take it over a stretch of 4,500 nautical miles.

A large plant is provided for the electric lights. There are three dynamos, each of 13,000 volt-amperes, which supply the four search lights each of 20,000 candle power. For lighting the interior of the vessel there are 350 incandescent lights of 10, 16, and 32 candle power. There is also the Sellner night signaling apparatus. Besides this plant there is a portable Gramme light machine, which supplies an arc light of 3,000 candle power, and besides the two principal engines there are, in all, 38 independent machines on board.

The armament of the vessel consists of two Krupp 24 centimeter breech loaders of 35 caliber length. They are mounted on hydraulic carriages and fire in barbette, with a range of from 260° over the bow and stern to 130° over each side. There are also six 15 centimeter Krupp guns 35 calibers long, that are arranged at different levels on the sides; and then there are two 7 Uchatius guns for the boats and for field service. Besides these there are 11 rapid firing guns of 47 and 37 millimeter caliber on board. And finally, there are a number of torpedo projectors which can operate in all directions. This vessel can command a wide expanse of sea, both above and below the water level, and, on account of its great speed, the ease with which it can be controlled, and its buoyance, it is a formidable opponent.—*Uber Land und Meer.*

PRESENT AND FUTURE DEVELOPMENTS OF ELECTRICITY.

By Dr. W. W. JACQUES.*

ELECTRICITY as a science dates back for centuries.

Electricity as an art has been developed within the memory of men still living.

The study of electricity as a science, that is, the study of electric phenomena and laws for their own sake, independent of the uses to which they may be put, began when Stephen Gray, nearly two hundred years ago, divided bodies into conductors and non-conductors, and thus made the conception of an electric current possible.

For a hundred and fifty years after that investigators in the field of electrical science, working largely in the laboratories of the grand old German universities, were busy finding out how electricity might be produced, what were its laws of action, how it could be measured and what it was capable of doing.

Thus was the *science* of electricity built up. Thus was the knowledge gathered together that later should be put to use. This was the time of plowing and sowing. During the last few years the harvest has begun to come. Now is the time of gleaning.

In the brief half hour allotted to us this evening, I want to view with you the harvest that is being gleaned, and particularly with the aid of the lamp that electrical science places in our hands, and look forward into the future and see what the fuller harvest is likely to be.

Electricians are very fond of telling us that nobody knows what electricity is; that, though we know perfectly well many different ways of making it, ways of bottling it up and storing it, ways of measuring it with greater accuracy than we can measure anything else, and though we now use it so generally that it enters into the daily life of us all, they tell us that nobody knows what electricity is.

And yet, recent investigations, carried out in part in those domiciles of scientific investigation, the German universities, and carried out in part in our own country, enable us to say with as much accuracy what electricity is as we can say what those other great forces of nature, sound and light and heat, really are.

When we speak of light, or sound, or heat, we feel that we are dealing with familiar things—things so familiar to our every day life that it seems useless to try to define or describe them. Every day the sunlight fills all space; it dazzles our eyes; it falls upon the objects around us and makes them visible; and though through the evening, when the sun is gone, we substitute for awhile a gas flame, or a candle, or an electric light, we have then through the day had so much of it that at night we are glad to be rid of it and have darkness for our hours of repose.

So, too, from babyhood to old age, all day long and every day, we are listening to one or another sound, whether the voices of friends, or the busy hum of city life, or the delights of music, or the ticking of the clock at night. Indeed, so constantly are our ears filled with sounds that when we go alone on to a high mountain, or a desert plain, where there are no trees to rustle with the wind, the silence is painful and oppressive and awful.

Heat, too, is equally familiar, perhaps even more so, for what is more familiar than the warmth of sunshine? And is not the fireside the very center as well as emblem of our home?

When, however, we speak of that other great force of nature, *electricity*, we feel that we are departing from familiar ground. It is shrouded in mystery; it is something we cannot see or hear, something we cannot easily describe or define. We speak of it in the same breath with spirits and with ghosts. The reason, I take it, is because the human body has no organ especially adapted to recognize electrical phenomena. While the eye receives the ray of light, the ear the ray of sound, the presence of electricity cannot be detected by either of these senses.

Electricity cannot be seen or heard; it is tasteless and odorless.

Subjectively considered, then, electricity eludes our grasp.

Objectively, however, electricity is as familiar to us as light, or sound, or heat. Its phenomena have been as carefully studied, and its laws are as accurately known.

Let us for a moment recall the physical explanation of light and sound. Let us picture to the eye of the imagination the mechanics of a ray of light.

When we stand out of doors on a cloudless night and look above us, we see a multitude of stars. The telescope tells us that some of these are suns, some are moons, and some are other worlds than ours.

The nearest of them is distant millions of miles, and yet we can see them. There is a chain of something linking the star at which we are gazing to the eye. This chain we call, familiarly, a ray of light. Physicists tell us that along the pathway from the star to our eyes there are chasing each other with enormous speed a multitude of waves of light.

If we turn our eyes to another star, it too sends to our eyes its waves of light. If we go to a distant part of the earth, the same stars send rays of light to us there. And so we find that each of the multitude of stars is radiating ceaselessly in all directions multitudes of waves of light.

Between us and the stars, and between the stars extending everywhere through visible space, is the medium that transmits these waves, crossed and intercrossed continually with countless waves of light—a medium rarer than the rarest gas—the medium that is still left in space when we remove from it all solids and liquids and gases—*the ether.*

Objectively considered, then, light is a wave motion of the ether that everywhere surrounds us and fills all space. By a similar wave motion, but in a coarser medium, the air sound is transmitted from place to place.

By means of his vocal organs, a public speaker moulds the current of air that issues from his lungs into waves of sound. These waves of sound are radiated in all directions and fall upon the various listeners' ears.

Something analogous takes place when we drop a pebble on to the surface of a placid lake. From this center of disturbance waves of water are radiated in all directions until they reach the shore. Waves are likewise radiated downward to the bottom of the lake, and fishes have organs, like our ears, that enable them to take cognizance of these vibrations.

In the case of waves of water, or waves of sound, or waves of light, we know there is no bodily transference of a particle of water, or air, or ether, from the center of disturbance to the shore, or ear, or eye. Each particle moves at the most only through a minute fraction of an inch; but each pushes the next, and this the next, so that motion, and not matter, is what is transmitted to a distance. Indeed, this propagation of motion, in contradistinction to propagation of matter, is the essential characteristic of wave motion.

Who has not seen a wave pass over a field of grain? Each particle bows its head but for a few inches, yet the wave passes on to the utmost limit of the field.

Sound, then, is a wave motion transmitted through the air. Light is a wave motion transmitted through the ether. But both of these media are also capable of having set up in them currents in which there is an actual bodily transference of the medium from place to place through considerable distance.

In the case of air, we call this motion the wind. In the case of the ether, we call it a current of electricity.

As wind is the bodily forward motion of the medium whose vibratory motion we call sound, so a current of electricity is the bodily forward motion of the medium whose vibratory motion we call light.

We may, perhaps, best get a realistic conception of electric currents, whether flowing through open space or confined to a specially provided metallic conducting path, by first picturing to ourselves the phenomena of of air currents, with which we are more familiar, and then mentally transferring these phenomena from the air to the more subtile medium, the ether. The analogies are very striking, and will materially aid the imagination in picturing electrical phenomena.

In the islands of the Pacific Ocean there is almost always a breeze, either from the land to the water or from the water to the land. In the daytime the island is heated by the sun, its air is rarefied and rises, and the cooler breeze rushes in from the ocean to take its place. At night the island cools, the air descends, and an outward breeze is produced. There is always a breeze from an area where the air is condensed, and toward an area where it is rarefied. This local condensation and rarefaction of the air are the cause of breezes and winds and hurricanes. The maps issued by our weather bureau show areas of high and areas of low barometer, and the direction of the wind is always from the one to the other.

If, instead of allowing the wind to blow freely through space, we confine it to a narrow channel, if, for instance, we produce an air pressure at one end of a long iron pipe, we get through the pipe a strong current of air, as, for example, in pneumatic tubes, in which the current of air carries along small carriages, in the tin pipes used to convey the hot air currents from our furnaces to the registers, and in the pipes used for distributing illuminating gas from the central gasometer to the houses about the city where it is burned.

The wind blowing through space is made evident to our eyes by its scattering of a handful of dry leaves, or dust, or bits of paper. It bows and bends the branches of the trees. A candle flame exposed to it is distorted, or instantly blown out. Its direction is more accurately indicated by the familiar weather vane, and its strength is measured, if we will, by the anemometer.

As with the wind of nature, so too with the electric wind. If we substitute for our Pacific island a metal ball suspended in mid-air by a silken cord, and let the ocean be represented by the surrounding atmosphere on a moist day, and produce upon the ball an area of *electric* condensation, or, as an electrician would say, a positive electric charge, we shall have an electric breeze blowing outward in all directions, which will last so long as the electrification of the ball is above that of the surrounding air. This may be made evident to the eye by placing upon the ball a handful of bits of paper, or dry leaves, or dust, any of which will be instantly blown away and dissipated in all directions. If a lighted candle can be brought near the ball, its flame will be bent by the breeze, and possibly be blown out.

If, instead of allowing this electric wind to blow away in all directions, we confine it to a narrow path; if, for instance, we connect the ball to the earth by a metallic wire, we get through the wire a strong current of electricity, whose direction may be determined by the electric weather vane, a magnetic needle, and whose strength may be measured, not with the anemometer, but by the galvanometer.

It is in currents flowing along metallic wires that the phenomena of electricity have been most carefully studied, and it is the phenomena of such currents that have therefore been for the most part utilized in electrical inventions.

Nature's wind is used to waft our ships across the seas, and it is perhaps not a wild idea to conceive of electric repulsion utilized to support and propel heavily laden air ships through the space above our heads; but it is with electric phenomena as they have been investigated and utilized up to the present time that we have to deal in this lecture, and this, as we have seen, means the phenomena of electric currents flowing through metallic wires.

What are some of these phenomena?

Electricity, or what is the same thing, a current of ether, passes readily through a copper wire. To the ether current the wire is hollow; in electrical terms, it is a good conductor. It also passes quite readily through an iron wire, but not so readily as through copper. It passes still less readily through a wire of carbon. It passes more readily through a large wire than through a small wire. In all wires there is more or less ethereal friction or electric resistance.

In virtue of this ethereal friction or electric resistance, the current heats the wire through which it passes, of course heating a small wire more than a large one, and heating an iron wire more than one of copper, and a carbon wire most of all. We see this in our household system of electric lighting. The current passes from the central station and throughout our houses to the lamps over comparatively large wires of copper, which it warms only slightly, but coming to the lamps it passes through a fine wire of carbon, in which the friction and consequent heating is so great that the filament becomes white hot, and were it not contained in a glass globe from which the air has been removed, it would take fire and disappear.

Again, an electric current flowing in a wire coiled around a bar of iron converts the bar of iron into a magnet, so that it may attract an iron armature placed near its end, and thus do mechanical work. The converse of this is equally true, and if we move an iron armature to or from the end of an iron bar around which a wire is coiled, an electric current will be set up in the same coil; and by means of the connecting wires may be carried to a distance and utilized. On this latter principle depends the dynamo machine which furnishes electricity to be used for light or power. On the former depends the electric motor that propels our street cars and furnishes power to many of our industries.

Again, the electric current flows through wires with enormous velocity, and consequently it offers an excellent vehicle for the rapid communication of intelligence, for telegraphy. A telegraph wire between two cities is merely a path through which the current may readily flow. At one end is a reservoir of electricity. The "key" is a device by which electricity may be allowed to flow into the line. By allowing small quantities of electricity to flow into the line at intervals of time in accordance with a prearranged code, and noting at their distant end their arrival, we may communicate any ideas that are capable of being expressed in such a code.

The arrival of these little currents of ether may be manifested to the eye in various ways. In the so-called needle telegraph, the current passing by a magnetic needle causes it to point in a given direction, just as the wind passing a weather vane causes it to point in a given direction.

If it were possible to have on one hill-top a reservoir of air under pressure, or wind, and a key by which small puffs of air could be let out at intervals in accordance with a prearranged code, and on a neighboring hill a weather vane, we might thus have a wind telegraph operated exactly as is the electric telegraph. But such a telegraph would be slow and cumbersome in operation, and is not likely to come into general use.

The most modern conception of electricity, then, is that of a fluid lighter and more subtile than the thinnest air.

An electrified body we conceive to be one in which more than a normal amount of this fluid is condensed.

We conceive of an electric current flowing in a wire as a movement of the electric fluid along that wire, exactly as water flows along a pipe.

Electricity has sometimes been called a fourth state of matter; that is, matter may exist in the solid state, like ice; in the liquid state, like water; in the gaseous state, like steam; and in the ethereal state, electricity. As water is more mobile than ice, and as steam is more mobile than water, so electricity is more mobile and subtile than steam.

As an illustration of the enormous velocity with which the electric current moves, let me tell you of a message

* Lecture delivered before the Deutsche Technische Verein, October 5, 1892.—*Electricity.*

that was sent from this city to Australia some years ago. Leaving Boston, it went overland to Nova Scotia, thence under the ocean to the Irish coast, thence across Ireland, under the Irish sea, across England, under the English channel, across the whole continent of Europe, and much of that of Asia, again under the ocean to Australia, from which point an answer was returned, and all inside of a single second.

But the telegraph, the telephone, the electric light, and the electric railway are old stories to us now. Let us look at some of the things that have been more recently accomplished, and some of the things we may expect electricity to do in the near future.

One evening, not many weeks ago, I was invited to witness some experiments in sending photographs over a wire by means of electricity. You may imagine that I went with a good deal of interest to the laboratory of my friend. The laboratory consisted of two rooms. In one was an ordinary photographic camera, a small developing closet, and on a table in the middle of the room a cubical box, in one side of which was a slit of sufficient size to receive a postal card.

From this box two wires stretched across the room to the partition wall and, passing through this, extended to a similar cubical box standing on a table in the middle of the adjoining room.

I was given an ordinary postal card and asked to write a short note upon it, and wrote "Good morning," "How do you do?" My friend then took the card and placed it about six inches in front of the camera, where it was well illuminated by an electric lamp. Then he pressed the button of the camera, then took the plate holder to the developing closet, and presently reappeared with a hastily made negative which he dropped into the slit in the cubical box on the table in the middle of the room. I then went into the adjoining room and there, issuing from the corresponding box on the table in the middle of the room, was a piece of thin paper the size of a postal card, on which appeared in fac-simile the words I had written, "Good morning." "How do you do?" There would seem to be no reason why the sending and receiving boxes, instead of being in adjoining rooms, should not be placed one at one end of the wires in Boston and the other at the other end in New York, and thus letters written in the one city could be instantaneously photographed to the other, and beat the United States mail by six or seven hours.

Another experiment, in which I have taken part only this last week, was to sit in my office in Boston and talk by long distance telephone with friends in Chicago, more than a thousand miles away. And this, too, as easily as if my friends had been sitting with me in the same room.

During the Centennial Exhibition in Philadelphia, Prof. Bell exhibited his then undeveloped telephone, which, though it whispered only feebly and imperfectly, was declared by Sir Wm. Thomson to be "the greatest marvel hitherto achieved by the electric telegraph."

At the Columbian Exhibition, soon to be held in Chicago, we shall see that invention grown so big that it will talk loudly and clearly between that city and New York.

Another invention that must soon come—an invention whose underlying principles have been already worked out—an invention that is only waiting for some ingenious inventor to make, is a good method of electric signaling between two vessels approaching each other in the midst of a thick fog at sea.

Let us imagine such a device applied to two ocean greyhounds approaching each other with a combined velocity of forty miles an hour through a heavy fog in a dark night. The lights are useless, for even an electric search light will not be visible a mile away. The steamer's whistle is useless, for the fog soon absorbs the sound, and yet these two vessels may be rushing immediately toward each other with a force and velocity that in case they meet shall mean total annihilation.

But there is no need of such danger. Means of producing electrical signals on the one vessel already exist. The ocean is an excellent medium for conducting these signals to another vessel many miles away, and means on the second vessel for detecting and recognizing such signals may easily be contrived.

Let us see how electricity steps in and points out a simple way by which such collisions may be avoided.

Suppose each vessel to be equipped with an insulated wire running from bow to stern, but dipping into the ocean at each end. Suppose one vessel to have included in this wire means for producing strong and rapidly alternating currents of electricity. Suppose the second vessel to have connected to its wire an ordinary listening telephone.

Electrical undulations will be radiated from the first vessel through the water in all directions until, reaching the second vessel, many miles away, they will be heard in the listening telephone.

By equipping each vessel both with means for sending out electrical undulations and for listening for any that might be received, each vessel would be made aware of the approach of the other, and the danger of collision avoided.

But the greatest electrical harvest to be gleaned in the near future will come when some inventor or engineer devises a method of converting the energy stored up in coal directly into electrical energy.

At present we burn coal under a boiler and produce steam, then we pass the steam through an engine and produce power, then the power of the engine turns a dynamo and produces electricity. We thus have a long chain of expensive machinery, at each link of which there is so great a loss that of 100 pounds of coal burned under a boiler only about five pounds appear as electricity—a clear waste of 95 per cent.

Some day there will be devised an electric generator in which coal is shoveled in at the bottom and electricity taken out at the top, thus using only one piece of mechanism instead of the whole chain used at present, and thus possibly converting the energy of the coal into electrical energy without this enormous waste.

It is thus theoretically possible to get twenty times as much electricity out of a ton of coal, and consequently twenty times as much power, as we do now.

Let us see some of the results that would follow.

A transatlantic steamship that now burns 300 tons of coal per day would then burn but fifteen; or, with the present coal consumption, she would be able to cross the ocean in less than two days.

An electric locomotive carrying its own supply of coal and generating its own electricity would be able to haul a train of cars from Boston to New York in less than two hours.

The machinery of our great manufactories, which now requires to move it work equivalent to that which could be done by 2,000,000 men, could then be operated for one-twentieth of the present cost.

In order to get an idea of the value of such an invention, let us see what the steam engine has done for us, and then imagine what an invention twenty times as efficient could do.

"Some time before his death in 1819, while resting from labor in his old age, James Watt, the inventor of the steam engine, when asked to allow his fellow citizens to honor him with a seat in Parliament, refused, saying that he had given employment to the better part of a million of men, and had earned the right to rest from work. To how many millions of men since then has his invention given employment?" How immensely has the working power of our people been increased, and how enormously have the comforts and luxuries of life been multiplied by the aid of the steam engine.

The steam engines of the world to-day are doing work that to be accomplished without them would require 1,000,000,000 of men.

In Massachusetts alone there are to-day on our railways 2,000 locomotives doing work equivalent to that of 2,000,000 horses, or 40,000,000 men. In our factories are steam engines engaged in spinning and weaving and forging, and great marine engines moving our commerce, that do the work of many millions more.

I have estimated that were the 60,000,000 people in our country all slave holders and all the rest of the world their slaves, each could not have, without the steam engine, the comforts and luxuries he has to-day.

Attempt now to conceive the benefits of an invention twenty times as efficient as this, and the figures become such that the imagination staggers under their weight.

THE INVENTOR OF THE LIGHTNING ROD.

By JOSEPH J. KRÁL.

WHEN the newspapers lately announced the names of eminent electricians which are to adorn the Electrical Building at the Columbian World's Fair in Chicago in 1893, we were surprised, nay, disappointed, to find that the respective officials left out the name of a man of science whose merits would fully entitle him to that honor. We mean Prokop Divis, the man who, before Franklin, discovered the identity of lightning and electricity, and the issuing of electricity from metallic points—two important truths which led him to construct a lightning conductor. But his modesty (he was a Catholic priest and a thorough scholar) and the ignorance of others combined caused his name nearly to be forgotten. The "Encyclopædia Britannica" knows nothing of him, while the German "Conversations Lexicon" of Brockhaus (vol. v., page 406) disposes of his two great discoveries exactly in two sentences. The only mention of him we find in English literature is a short sketch in the *Historical Magazine* for February, 1868 (page 93, article xii.), which is a translation from a French periodical. As the life of Divis is of itself sufficiently interesting, we hope to be justified in presenting a few more details of his life to the readers of this magazine. Our article is based chiefly upon a sketch in the Bohemian Encyclopædia of Rieger and Maly (vol. i., pages 209, 210, and vol. iii., page 941).

Prokop Divis (Dyiv'ish) was born on the 1st of August, 1696, in the town of Zamberk (its German name is Senftenberg), in Northeastern Bohemia, of Bohemian parents. At the gymnasium of Znojmo he received the rudiments of higher education, and afterward entered the Premonstratensian order at Luka. On November 30, 1720, he bound himself with the three monastic vows, and six years later took the holy orders. On account of his high scholarship, he was soon after appointed Professor of Philosophy in the Lyceum of Luka. A special feature of his lectures were various experiments in physics, with which, contrary to all precedents, he liked to illustrate the subjects discussed. It will be remembered that the Church has never looked with favor upon natural sciences. After a year had passed, Divis was obliged to change his subject and lecture on theology. He distinguished himself also in this new field, and accordingly, on the 5th of August, 1733, the University of Salzburg conferred upon him the degree of doctor of divinity.

He had been longing for an opportunity to devote himself to scientific research. His wishes seemed to be fulfilled when he was ordained parson of the parish of Prendice (Pren'dyitsch), a small village in Southern Moravia, near the city of Znojmo (Znaim on English maps). Here all his leisure was given to physical experiments; with especial care he studied the properties of water and fire (oxidation). In 1741 he became prior of the Lukan Convent, and consequently had to discontinue his scientific labors for a few years, as the duties of the new office required all his time. Besides, the Austro-Prussian war had just broken out,* and a double care devolved upon the shoulders of the new prior. Throughout the war Divis faithfully performed his duties, but as soon as peace was restored to Moravia he resigned his dignity and returned to Prendice to resume his favorite work. His parish was a small one, and thus Divis was enabled to spare time enough for scientific inquiries. He now entered upon an examination of electricity. Pursuing the safe empiric method, Divis based all his conclusions and estimates upon careful experiments. His observations of thunder storms led him soon to a discovery that lightning was but an electrical spark—that in his laboratory he could imitate thunder and lightning on a small scale—and he resolved to try if it were possible to make thunderbolts harmless. How thorough his studies were may be gathered from the fact that he worked out a complete theory of atmospheric electricity, a treatise on which was published from his papers after his death.

Another important discovery followed soon after. Divis found out that metallic points would both attract and discharge electricity more speedily than anything else, and proceeded to make a practical application of the newly discovered truth. About the same time Franklin, on this side of the Atlantic, was receiving his first lessons in electricity from Dr. Spence.

The fame of the electrical experiments of Divis soon reached the imperial court of Vienna, and the Emperor Francis Stephen, who was somewhat of an amateur naturalist himself, invited Divis to Vienna, to repeat his experiments in the halls of the imperial castle. These performances were also honored by the presence of the Empress Maria Theresa. The imperial couple were highly pleased with the experiments, and, to show their esteem for Divis, they presented him with two heavy golden medals with their busts engraved upon them.

In 1750 Divis demonstrated his superior knowledge of electricity in an amusing way. Father Francis, a learned Jesuit, was about to make some experiments with his electrical machine at the Vienna court. While he was making some preliminary remarks, the Bohemian scholar, who had concealed a number of small iron nails in his periwig, approached the machine and viewed it closely from all sides, as though he were going to make a critical examination of it. His true intention was, however, to take away all electricity stored on the metallic balls, in which he succeeded without touching the machine. Imagine the horror of Father Francis when he finally came to perform his experiment, and found that, although his accumulators were well insulated, all his electricity was gone!

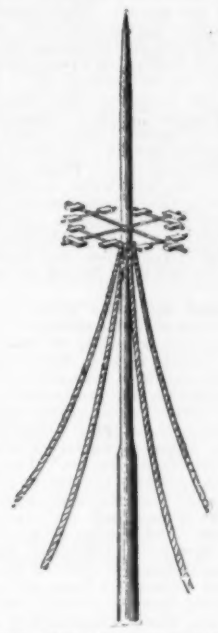


FIG. 1.—THE TOP OF THE LIGHTNING ROD OF DIVIS.

In 1753 Prof. Richmann, of St. Petersburg, while observing a storm from a hut, was killed by lightning descending an insulated iron bar specially erected for the purposes of the study. Upon learning of the fate of that martyr of science, Divis drew up a memoir on that unhappy occurrence, in which he demonstrated that the iron bars, as used by Richmann, were both unsafe and dangerous, and clearly showed how, in case of a storm, the danger of a lightning stroke could be averted by means of a conductor, the idea of which had already matured in his mind. This treatise he sent to the famous mathematician and naturalist, Euler, then President of the Berlin Academy of Sciences, asking for his judgment. But his application was in vain; the academy failed to understand his reasoning. This is one of the numerous instances which go to show that it is always the individual workers to whom we have to look for any advance in science rather than learned societies. When Franklin's account of his discovery was read in the British Royal Society, it was laughed at by the connoisseurs.

Divis was not discouraged by the cold reception with which his work had met in Berlin, but went on to construct his lightning rod. After all that was necessary had been prepared, the conductor was erected on the 15th of June, 1754, near the residence of the parson, for Divis, in order to avoid all risks, gave up the idea of placing the lightning rod upon the building, but built it separately in the free field near the building. The lightning rod of Divis was constructed as follows:

FIG. 2.—A HORIZONTAL VIEW OF THE CROSS BARS.

A pointed, slender iron bar formed the main part of the machine. Fastened to it were two cross bars, thus making four arms, across each of which, in turn, a shorter bar was laid. And each of the twelve extremities so effected bore a box filled with shavings of iron in which twenty-seven brass needles were stuck, mak-

*Charles VI, King of Bohemia and Hungary and Emperor of Germany, died in 1740, leaving his dominions to his daughter Maria Theresa. Frederick the Prussian thought this a good opportunity to rob the queen of some of her territories, and he immediately, without any right, and without even a declaration of war, invaded Silesia.

ing three hundred and twenty-four needles in all. The main bar was supported by a wooden column sufficiently high (forty-eight feet at first, afterward one hundred and thirty-two feet) to secure protection for the building and its immediate surroundings. Several iron chains connected the main bar with the earth. The effect of the machine was to divide the lightning into as many sparks as there were needles (three hundred and twenty-four), and thus to lessen its force. It might, therefore, more properly be called a lightning divisor.

Scarcely had the rod been erected when a storm came rushing on from the north. Thunder clouds hung over Prendice, and occasionally white shafts of lightning were seen darting from the clouds and flying toward the conductor. In a few minutes a white cloud enveloped the machine, and the storm soon passed away without doing any damage. For two years Divis continued experimenting with his lightning rod; the results were published by Dr. Scrinci in the Prague News (1754). Having satisfied himself in regard to the utility of his new machine, Divis offered to the emperor a plan for erecting a number of conductors in various parts of his empire. The emperor submitted the plan to Viennese mathematicians, who were, unfortunately, a little behind the times, and reported unfavorably upon the Bohemian's proposition. The plan was consequently never carried out. Abbot Marci, speaking about the report of the Viennese "connoisseurs," says, in a letter to Divis, "Blasphemant, quae ignorant" (They blaspheme that which they do not understand). And at last, in 1756, Divis was compelled to remove his lightning rod. There had been a very dry summer that year, which the farmers of Prendice and the neighboring places ascribed to Divis' machine! One day an angry crowd came to the parsonage and tore down the iron bars. The authorities then ordered Divis to take away his machine, and he accordingly removed it and deposited it at Bruck, where it has been kept to this day.

There is a marked similarity between the treatment which the invention of Divis suffered at the hands of his neighbors and that accorded to Franklin's conductor in America. When, in 1755, Massachusetts had experienced a sharp shock of an earthquake, the judgment of public opinion was pronounced upon Franklin's rods as the direct cause of the earthquake. As late as 1770 a Boston clergyman preached against the lightning rods as "impious contrivances to prevent the execution of the wrath of Heaven." The difference between the relative positions of the two inventors was that in America a divine denounced a layman, whereas in Moravia laymen denounced a divine. We unwillingly recall the words of Madler: "In all times and in all countries the enemies of truth and light pretend to be fighting for the honor and glory of God."

Thus Divis was prevented from perfecting his machine, which would have doubtless been wrought by him into a different, more advantageous shape but for the official order. Divis felt himself obliged to give up his studies and experiments in electricity, and his versatile genius turned to a new field—music. He was well acquainted with acoustics, and as a Bohemian he possessed likewise a personal liking for music, and before long his creative genius enriched the musical world with a new instrument which he named "denis d'or."* This instrument is played by both hands and feet, like an organ, and it can give the sound of almost any stringed or wind instrument, from the *pianissimo* to the *fortissimo*, as it has as many as one hundred and thirty registers. In its effect this instrument is equal to a full orchestra.

This was the last great work of Divis, and on the 25th of December, 1765, the untiring worker quietly departed this life.

Personally, Divis had the true appearance of a thinker. In his early youth his health was rather delicate, but it improved steadily after he began his electrical experiments and never failed him again, although he was constantly at work. Oftentimes he was so deeply absorbed in his experiments or observations that he would not notice his friends coming to see him, until a servant reminded him of their presence by pulling his sleeve. The steady mental work gave his face a serious, unfriendly mien, which disappeared, however, whenever he happened to be in a circle of his friends. His guests, among whom there were many distinguished persons, he always entertained courteously. Besides his mother tongue, the Bohemian, he also knew Latin, German, and French. From the papers he left there was printed, after his death, a treatise entitled Langst verlangte Theorie der meteorologischen Electricitat (The Long-sought Theory of Atmospheric Electricity), Tubingen, 1768.

Prokop Divis is an interesting example of an ideal scholar. Originally he studied science merely for the sake of finding out the truth; but when he saw that the truths discovered by him could be utilized for the benefit of mankind, he utilized them. Undoubtedly he knew nothing of Franklin, and there is no evidence that Franklin ever heard of Divis; their discoveries in electricity were wholly independent of each other. But Franklin was the happier of the two because he found a people who understood him—the French; while Divis, by his social position, was prevented from perfecting his instrument. We must remember that Benjamin Franklin was a public man, who stood conspicuously before three countries, while Prokop Divis was merely a parish priest of a small Bohemian village, with few or no connections. Yet we admire his genius evinced by inventions so vastly different—a lightning rod and a musical instrument. These are wittily characterized in his epitaph, written by one of his contemporaries:

> "Ne laudate Iovem, gentes! quid vester Apollo?
> Iste magis deus est fulminis atque soni." †
>
> —*Popular Science Monthly.*

WATER ELECTRICITY.

FROM many observations and experiments M. Ph. Lenard finds that drops of water falling upon water or wet bodies generate electricity, the water becoming electrified positively, and the air escaping negatively electrified from the foot of the fall, and light impurities in the water diminish the effect considerably. The essential conditions of electrification are the concussions among the drops themselves and against the wet rock, no effect being due to the water's fall through the air and its dispersion by it. A jet of water falling from an insulated tank to an insulated pail electrified the latter positively, while the negative electrification of the surrounding air grew to several hundred volts. Sparks were obtained from waterfalls.

IMPROVED ELECTRIC FORGE.

GEORGE D. BURTON, of Boston, and Edwin E. Angell, of Somerville, Mass., have invented the following improvements, as described in their recent patent.

The object of this invention is to provide an electric forge for heating sheets of metal from which rakes, hoes, plates, shovels, and the like may be forged or stamped.

Fig. 1 represents a plan of this improved electric forge. Fig. 2 front elevation. Fig. 3 end elevation thereof, the segments of the converter ring being in transverse section. Fig. 4 front, side, and end views of a shovel forged under the electric heat of this improved electric forge. Fig. 5 a rake blank and a rake formed therefrom under electric heat. Fig. 6 plan and side elevation of a metallic dished plate formed under the electric heat. Fig. 7 hoe blank and a hoe formed therefrom.

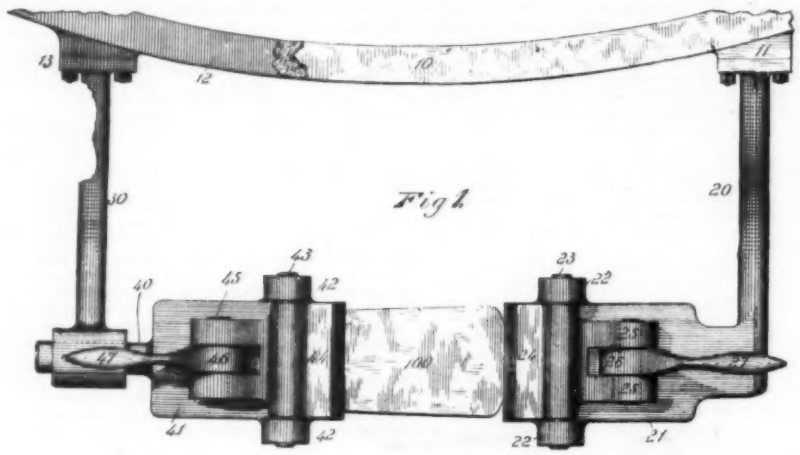
A current converter for transforming an electric current of small volume, measured in amperes, and of high tension, measured in volts, into a current of low tension or voltage and large amperage or volume is employed in connection with this electric forge to furnish the heating current therefor. The converter which we have used for this purpose comprises an annular core, preferably composed of different lengths of uninsulated or partially insulated heavy wire disposed side by side and arranged to break joints; primary coils composed of comparatively fine wire disposed at intervals around the annulus of the core and insulated therefrom; secondary coils composed of plates or sheets of copper disposed around said annulus between the primary coils and insulated therefrom and from the core, and two exterior heavy copper rings surrounding the structure. The primary coils are arranged in pairs, the coils of each pair being connected in series with each other and in parallel with every other pair and to the terminals of the primary circuit by binding posts mounted on a central support. The secondary coils are composed of copper plates, and all the positive terminals thereof are connected with one of the exterior rings and all the negative terminals with the other exterior ring, said rings thus constituting the positive and negative terminals of the converter.

Any converter capable of furnishing the required current may be used in connection with this improved forge.

In the drawings segments of the exterior converter rings are represented.

The upper converter ring 10 may be considered as the positive terminal of the converter and the lower converter ring 12 may be considered as the negative terminal thereof. The upper ring 10 is provided with a boss 11 and the lower ring 12 with a boss 13, said bosses being disposed at considerable distances apart on the circumference of the converter. A bracket 20 is attached to and depends from the boss of the upper ring 10, and a bracket 30 is attached to and depends from the boss of the ring 12, terminating in the same horizontal plane with the bracket 20. These brackets are composed of copper or other highly conductive material. The bracket 20 is provided with an arm 21 at its lower end, which extends substantially at right angles to the body of the bracket. The bracket 30 is provided at its lower end with a sleeve 31. An arm 40 is adjustable in the sleeve 31 at an angle to the bracket. The arm 21 consists of a broad flat plate provided with upwardly projecting lugs 22 at its opposite sides near its outer end. A rod 23 extends between the lugs 22, and a lever 24 is pivoted on said lugs. This lever is provided at its inner end with ears 25, between which is pivoted a cam 26, having a handle 27. The outer end of the broad arm 21 and the lever 24 constitute a clamp, the arm serving as the fixed jaw and the lever as the movable jaw thereof, said fixed jaw being provided with a recess 29. The adjustable arm 40 is provided with a broad platform 41, having lugs 42 at its opposite sides near its outer end. A rod 43 spans the space between these lugs, and a lever 44 is pivoted on said rod, the inner end of said lever being recessed and provided with a pivot pin 45, on which a cam 46 is journaled, said cam having an actuating handle 47. The outer ends of the arm 40 and the lever 44 constitute clamping jaws, the lower jaw being provided with a rabbet 48 at its outer end. These arms and their clamps are composed of copper or other highly conductive material, and, having broad clamping faces, they are adapted to receive the ends of the sheets or plates of metal to be heated.

In the use of this improved electric forge the arm 40 is adjusted in the sleeve 31 of the bracket 30 a distance from the arm 21 of the bracket 20 corresponding with the length of the sheet metal blank to be heated. The jaws are opened by swinging the handles 27 and 47 into the positions indicated by dotted lines in Fig. 2, the cams 26 and 46 serving to lift the outer ends of the movable jaws. A plate or blank 100 to be heated is then laid upon the ends of the fixed jaws, its opposite ends resting in the rabbets 29 and 48, formed in said jaws. The handles of the cams are then swung outward, whereby the upper jaws are closed upon and bite the ends of the blank. An electric heating current is then passed through the blank spanning the space between the clamps and heats said blank to a forging temperature. The blank is then removed from the forge and subjected to a metal forging, stamping, or shaping apparatus, whereby the desired article is rapidly and economically produced.



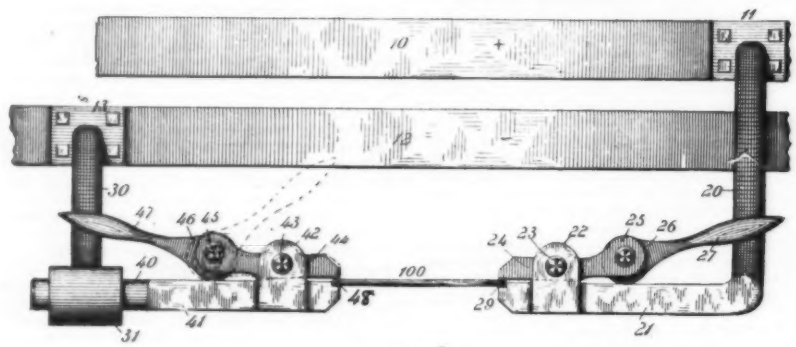


Fig 2.

BURTON'S IMPROVED ELECTRIC FORGE.

THE ELECTRICAL USES OF MICA.*

By CHARLES W. JEFFERSON and ARTHUR H. S. DYER.

AN armature and its commutator consist of the combination of two elements; namely, electric and magnetic conductors and insulators. In the earlier days of armatures, the electrical and mechanical dimensions and proportions of the conductors were considered of prime importance. The first armatures were small and the electromotive force low, and consequently little attention, comparatively, was given to the element, insulation. Lately, simply paper, cloth, convolutions of ligatures, or these materials impregnated with shellac or similar insulating varnish or paint, were employed for the purpose of preventing leakage or short circuit. To remove the solvent of the shellac, the armatures were baked for twenty-four hours. Judging from the variety of materials used at present, and the changes from one material to another, it would seem that the insulators are now receiving their share of consideration, while the core, wires, commutator sections and other conducting portions are secondary details. Why so much difficulty with armature insulators and so little with other insulators, such as line

* Denis is a French translation of the Bohemian name Divis. D'or means "of gold."

† "Do not praise Jove, nations! What is your Apollo? This man, rather, is a god of both the lightning and the sound."

* Lately read before the American Institute of Electrical Engineers, New York.

insulators? Because, in the former, not only must the material be of extremely high resistance, but also unaltered under the effects of heat, and must be crowded into very small quarters. Space must be economized. If the electric current or heat alone were present, and if space were not so much limited, the problem would be easily solved. It yet remains to be proved that any known substance is absolutely a non-conductor—nor is the resistance of a given conductor constant. Unfortunately for the armature constructor, the worse the conductor, the less the resistance with increase of temperature. An extra current is produced in metals upon variations of current. A diminishing of current occurs when first entering a substance of high resistance. Finally and gradually the current becomes constant. This action for convenience is often called polarization. As this property is noticeable only in long lengths of the insulating material, it has little bearing upon any of the armature elements other than in connection with the covering of the wires. The substance possessing the property of polarization in a marked degree is gutta-percha.

Paper or fabrics by themselves should never be used as an insulator, because when moist they conduct a current so well that they may properly be termed semi-conductors. A coating of shellac or oil on almost any substance enormously increases its resistance, and protects porous and deliquescent substances from water. Paper thus covered serves, with machines of low electro-motive force, the purpose of preventing leakage, but by no means perfectly in practice with large machines. Its advantages are more in the nature of convenience and cheapness than of efficiency.

Paper which has been thoroughly dried is of very much higher resistance, so high that it falls under the head of non-conductors, and, therefore, the shellacs should not be applied until after the paper has been subjected to a thorough drying process.

It is a peculiar property that a given substance in a compact condition is of very marked higher resistance than when powdered or comminuted; for example, pulverized glass is a semi-conductor, while sheet glass is as high in resistance as silk. This property has been noticeable in armature practice. If the insulating material is cracked here and there, it is unfit for armature use. The cracks are in nature of interstices between the particles of a powder, and at the cracks the material is in part ground. The explanation may lie in the distinction that the pulverized material has more surface, or that damp air exists in the spaces between the particles, or that a spark can traverse a gas better than a solid, or that each particle becomes coated with a film of moisture. The last seems the most probable, because the best surface concentrators of water usually exhibit the property most strongly.

The locations of insulation in an armature are between the armature disks to prevent eddy and Foucault currents; between the core and the windings to prevent the current from short circuiting the coils through the core and burning out the armature; between the commutator sections to prevent leakage from one coil to another; over projections or in grooves in the core; and around in the wire to guide the current in convolutions. All these parts, even in the best made armatures, become more or less abnormally hot. Means have been planned and sometimes put into practice for cooling the parts, and thereby saving the insulation. One method consists in constructing the armature after the style of a fan or with large radiating surface; another in equipping a device to blow out the sparks of the commutator, and again, in using cooling insulating liquids. With whatever precautionary means the machine is equipped, the parts, either accidentally or through inefficiency of means, will become abnormally hot. The machine will be injured if combustible materials form the bulk of the insulator. The materials of an ideal armature consist of copper, iron, and a heat-proof and water-proof non-conductor. If the material is combustible, or altered in its chemical nature by heat, its resistance is changed and generally lowered. Manufacturers of incandescent lamp filaments know that complete carbonization cannot take place except at a very high temperature, like 3,000° Fahrenheit. An armature may rise to 500°. At this temperature easily carbonizable materials, such as linen, cotton and other forms of cellulose, are weakened, blackened and the resistance reduced. Shellac, although blackened at this temperature, is converted into those compounds whose resistance is not lowered. Shellac forms an exception, therefore, in being charred by such a temperature without reduction of resistance.

There is a greater detriment than chemical change by heat. The material cracks, becomes somewhat comminuted, and the resistances, both mechanical and electrical, are therefore greatly reduced. If paper or cloth, or even shellac, is depended upon as the insulating material rather than as the binding material, it is not electric proof; because, principally, it becomes, when charred, fractured at numerous points, if not completely pulverized. As to why shellac is not appreciably lowered in resistance by partial carbonization may be because it is an animal substance.

One of the most important attributes of an armature should be its rigidity. It should be like a rock in this particular. If the insulation should consist of a soluble material, for example, and the same dissolved out after the completion of the armature; or of some material that would be reduced in size by heat, then the wire and bolts would soon become loose from the rapid rotation and vibration, and finally the armature would be useless. Change in volume of the insulators has caused nine-tenths of the armature breakdowns.

In the matter of insulation between the disks, it was found that oxidized or rusted laminated armature disks would insulate without any addition of paper or similar insulating films. The only difficulty with such a construction is one of degree. Iron rust insulates, and it is heat proof; but it does not insulate sufficiently to compensate in most instances for its simplicity and cheapness, and, besides, it is not applicable to any other part of the armature than between the laminæ of the core. The great advantage lies in the extreme thinness of the oxide coating, whereby a large amount of iron is obtained in the core. A modification has been suggested, which consists in placing thin mica sheets between every half dozen of the disks. Again, iron wire or ribbon rusted has been employed for armature cores. The wire or ribbon is formed into a ring, around which is the electric conductor. Another modification consists in "casehardening" the iron, and also in japanning the surface. As to commutator insulation, natural mica sheets have been almost universally employed.

If it were not for the matter of mechanical construction and heat, shellacked glass would be a good armature insulator. It could be moulded into any form and made of any degree of thinness. Its objections, however, are well known. Very gradually, and more so than would be conjectured, mica made its appearance in armatures. The introduction of mica into practice appears to have been brought about in the following manner:

An accident would happen to an armature, and before the next night it must needs be repaired. In order to make the temporary remedy, mica sheets or bars would be interposed. In the case of subsequent accidents, the portion repaired by mica was the last to yield. Therefore it was proposed to build the armature primarily with mica. But this change took place very, very gradually, but surely. Manufacturers of stoves, the leading houses being also importers of mica, soon experienced a growth in the mica department of their business, until at present some import more for the electrical industry, especially for armature use, than for stoves. Why it was not employed from the first, no one could positively assert, otherwise than to guess that no one probably thought of it, or insulation was not considered of much comparative importance, or cheapness of material in construction was allowed to counterbalance efficiency of action and durability.

Of all substances, mica probably is the best material for use in armatures, if it is desired to obtain not only efficient electric insulation, but also durability under the influence of heat. The highest temperature to which an armature is subjected, even by short circuit or bad construction, will have no injurious effect upon mica. Mica, thick or thin, may be held in a gas flame without cracking, burning, or melting. It remains unaffected. The reason of this is better understood when it is remembered that it consists of aluminic silicate, containing also potassic, sodic, and lithic silicates, and some ferrous and ferric and manganic oxides. Its chemical constitution varies.

One quality of mica is that which is commercially termed amber mica, and is usually mined in Canada. It is so named from its appearance, and not because it is amber or in any other way similar to it than in its color. India mica is a commercial form noted for its uniform cleavage, great thinness of its laminæ, flexibility without fracture and its resistance, which is much higher than that of amber.

Carolina mica is another variety. It is obtained in sheets in the western part of North Carolina. It is the best mica for stoves, but it is too hard for electrical purposes. Mica occurs in so many specific forms that particular names have been given to it.

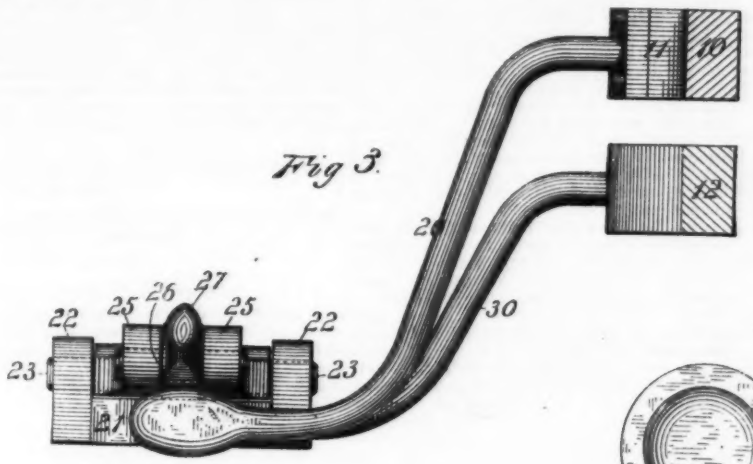
Muscovite is one of the most common varieties. It occurs in different colors, namely, a dark green, yellow, brown, white, and gray. This is the form usually found in small scales in granite, gneiss, and mica schist, and at the same time it occurs in larger, tougher sheets than any other form. A complete scale is irregularly hexagonal in shape. Lepidolite, or lithia mica, has a pearly luster, as distinguished from the vitreous luster of muscovite. Its scales are usually very small, and it is found in limited varieties of granite and gneiss.

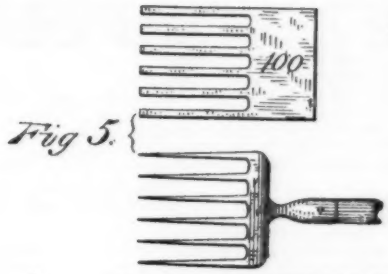
Cryopholite is a sub-variety of lepidolite. A characteristic feature of the form meionite consists in its occurring much cracked within. It has been found in geodes. Biotite is a form found in volcanic rocks in small scales. It contains much iron and magnesia compounds. Phlogopite occurs usually in limestone. Its sub-varieties are aspidolite and manganophyllite. A very brittle variety is lepidomelane. It is also practically opaque. Its sub-variety is astrophyllite.

The insulating power of mica is superior to that of any other substance applicable to armatures. An advantage peculiar to itself is its even, laminated structure. How wonderful is the thinness of its individual layers! A piece of ordinary writing paper is about 0·005 in. Mica layers have been obtained of a thinness of 0·00003 in. Mechanical difficulties prevent its being split thinner. By pasting it upon a hard surface and splitting it off as much as possible, the remaining fragments are so thin as to become beautifully iridescent. The builder of armatures can therefore split the sheets into any desired and uniform thickness with great ease and accuracy. An interesting property of mica, and one not generally recognized, is its homogeneity of structure and clear transparency, although so black when thick. The writer used a piece one-quarter of an inch thick for observing the late solar eclipse. The effect was better than with smoked glass and as efficient as black glass much thicker.

A valuable property of mica in connection with commutator insulation is its proper degree of hardness, whereby it does not wear away too rapidly under the action of the brushes. If rubber were used, for example, even if it did not burn, yet it would wear off and sparking result, because the commutator surface would not be truly cylindrical. The brushes would be set into vibration.

Again, mica is capable of the finest pulverization, so that any wearing which does take place does not result in the liberation of gritty particles, which would also cause sparking. Such mishaps occur with hardened artificial plastic insulators. The insulation should be





BURTON'S IMPROVED ELECTRIC FORGE.

just so thick that the current cannot jump across from one section to the other.

Although so superior for armature insulation, mica is, in its natural structure, accompanied by certain objections, which, in trying to overcome, were more serious than had been anticipated, as it was not until after a long series of trials that a successful article was produced, and not until a novel apparatus for cheapening the process of manufacture was devised. The apparatus is now in operation on a large scale. The description at present is confined, however, to the article, and to full information of its structure, manner of using and properties.

The objections alluded to are: Mica as found in nature occurs in flat sheets only. It has a high degree of elasticity, so that when once bent and released, it assumes its original form. If folded, its brittleness causes fracture. If the natural sheets are compressed in a mould, to try to form armature insulator heads for instance, it is completely broken up.

Secondly, natural mica sheets correspond financially to plate glass. The larger the sheet, the higher the cost per square inch. Mica in small pieces, from four to six square inches, is exceedingly abundant and very cheap. It is often called waste mica, because very limited in its uses, and consisting often of trimmings from larger and more useful sheets. In medium and large sizes of armature the naturally built up mica is so expensive as to be objectionable, although not so much so as to entirely prevent its employment.

Thirdly, between the hundreds, nay, thousands, of thin layers, damp air can enter, and also water, accidentally, which cannot easily or effectually be removed.

Fourthly, mica splits so easily that handling causes injury.

Fifthly, mica cannot be cut transversely to advantage. The edges are unworkmanlike, being ragged and jagged. Neatness in drilling, sawing, and turning is difficult.

Micanite.—Among the attempts which have been made to overcome these objections are those involving the use of pulverized or comminuted mica, which is mixed with a liquid cement and stirred into a paste. While still soft, the mixture is rolled or compressed into any desired form, as if consisting of so much plaster of Paris. In order to give it sufficient strength, one-third of the product is cement. The mica sparkles here and there on the surface, as it glitters on granite. This article should be called a cement insulator, and not a mica insulator, because the current can flow in a straight circuit through the plate without encountering any mica. The cement forms numerous rectilinear paths for the current independently of the mica; and therefore the product in no sense is an equivalent of mica.

A modification of this type of insulator consists of a coarse and thick textile fabric, whose pores and meshes are filled with a mixture composed of comminuted mica and a suitable adhesive substance. Another consists of finely divided asbestos mixed with pulverized mica, silicate of soda and sulphur compounds. It is moulded by pressure into any desired form.

The comminuted mica cement type is useful in trolley wire supports and similar insulators, but for dynamos it is useless, not only for the reason stated, but because of its softening and running under slight heat, being so necessarily rich in cement. If the cement is that kind that chars, the mica crumbles apart. Mineral powders have been mixed with it to render it more fireproof.

An example of the manner of using non-comminuted mica between the core and the windings consists in covering the core with paper, laying sheets of mica over the paper, then laying on another sheet of paper, fastening the whole together by convolutions of cord or similar ligatures, and finally applying the coils. During operation, the paper and mica may shift from their positions, and thereby affect the rigidity of the armature as a whole. Again, the process of applying the pieces and keeping them temporarily in position requires repeated efforts and results in a display of crude workmanship.

The exhibits before you show practical results of work carried on for the purpose of overcoming the objections named.

Large Plates.—One of these plates is a yard square and 0·085 in. thick. Another is of the same size and 1 in. thick, and another about 4 × 12 in. and 1 in. thick. They have nothing to do directly with the armature, but could serve as foundation plates for a dynamo or motor. They are practically all mica. A *natural* plate of mica of the larger size would be a curiosity—a rarity. Any of the sheets may be cut up into any desired size and shape. The layers cling together much more tenaciously than in the natural plate. The path of least resistance from one side of the plate to the other is in a straight line, and a straight line intersects numerous mica sheets, and therefore the article is a mica insulator and not a cement insulator. These plates are made by such steps and apparatus that, when subjected to heat in the armature, no injury whatever is produced.

Further, they are superior to a sheet of mica as it comes from the quarry, in that they do not absorb water or damp air; in that they are stronger to resist either pressure or tension; in that they may be neatly and easily sawed and drilled; in that they are enormously less costly, and in that they are of about the same resistance. By picking the exhibit apart you can easily learn the structure. The mica of which it is composed is non-comminuted, but the pieces are exceedingly thin. The thickness is, by measurement, about 0·001 in., *i. e.*, about as thin as tissue paper. The sizes vary from two to six or eight square inches. In each layer of mica you may notice that the sheets overlap at their edges, and the cement between the layers is hardly noticeable. The former mentioned plate weighs four pounds and the latter 100 pounds. It is a convenient quality in connection with mica that it can be split into pieces of the thickness required for the particular device under the process of construction. This property is also possessed by the plates exhibited. A thin and long knife may be caused to force its way in any of the many planes parallel to the surface, for the purpose of reducing the thickness or obtaining several thinner sheets from one thick plate.

Some tests were carried on to determine the relative values of these plates and plates of comminuted mica and cement. Using the words of the electrician who originated and performed the tests, he says: "For the purpose of insulating armatures, any solid insulating material should possess considerable strength and should maintain its strength when submitted to a moderate degree of heat. One piece tested consists of ground mica and shellac, mixed together and rolled or pressed between plates to a uniform thickness. In order to test it, I placed it upon a steam table and left it for a minute, at the end of which period I tested its strength by pressing the end of a piece of wire against its surface with very light pressure. The end of the wire, which was blunt and made of copper, easily pushed its way through the sheet and left a hole when removed. In removing the sheet from the steam table it warped. The second plate consists of layers of sheets of mica, cemented together with overlapping joints. This sheet I placed on the same steam table used for the other sheet, and after one minute had elapsed, tried to thrust the same piece of copper wire through the plate, but without success, though exerting all the strength that could be brought to bear upon it by my hand. After the sheet had been on the steam table for five minutes, I placed it on a thick iron plate, laid a piece of the same copper wire upon its upper surface, put a second sheet of wrought iron on top of it, and put the whole into a hydraulic press. It was then submitted to a pressure of 2,000 pounds per square inch for one minute, and the result was the flattening of the wire and a very slight crumpling of the mica sheet on the opposite side. The plate was then placed between two copper plates, and a weight of about four pounds placed on the upper plate. The insulation resistance of the plate was then tested and found to be 25,500 megohms. I have used similar plates, similarly prepared, in motors, upon which a load of 50 horse power has been placed, the entire thrust of the motor being received by the plates, which in this case were less than one-sixteenth of an inch thick. The temperature was brought up to 650° F., sufficient to burn cotton and melt hard solder without injuring the insulation."

Curved Specimens.—Similar remarks substantially may be made about these as about the large plates. Natural mica plates could never be given a permanent set, or moulded into curved forms. The armature head consists essentially of an annular disk, provided with flanges around one or both peripheries. It is in one sense a continuous piece. The flanges, you may notice, are made separably and then fastened to the disks. There are no joints. Some of the peculiarly curved forms are furnished in order to illustrate that the article may be manufactured in any imaginable form of uniform structure, and in single pieces of uniform properties throughout.

Tubes.—In order to show the unlimited forms into which the material may be moulded, a tube several feet long is exhibited. It may be cut up for use in certain types of armature, or when long, for use on board ship, and in general interior conduit installations.

Stamped Forms.—The flat pieces of peculiar form could be made from the beginning in individual pieces, but it is much cheaper if stamped from larger plates. Before using the large plates for any purpose where an exact thickness is required, they are burnished or surfaced off by machinery. Some of the plates before you are in a crude state, and little scales here and there can be peeled off. The others are so different as to resemble a metallic surface, and, when struck, ring like metal. Some of the forms are for large commutators. Others are flat rings for field magnet cores. The very irregular flat pieces are for certain types of commutators. On account of the almost metallic qualities the product can appropriately be termed an "insulating metal." For convenience it is called micanite.

Commutators.—In equipping a commutator with this material, it is necessary to know something which has been learned by early users only through experience. The insulating and metal sections are put together in the usual manner, and the whole is heated to a temperature higher than that which it will reach in actual practice. While still hot, the elements are clamped tightly together.

Among the exhibits is a mass of odd pieces of mica, sometimes called waste mica; also you will find similar pieces split as fine as possible. These are the result of the first operation. The next step consists in putting them together in the manner shown in the exhibits; that is, in layers with overlapping edges. Between them are layers of a cement having those qualities which fit the product for the purpose intended. Until only recently these pieces were always laid on by hand. Their manufacture required one factory girl per cubic foot per hour. Now, one girl can do the work which formerly required twenty. The girl feeds the machine, and it does the rest. The amount of cement employed is practically infinitesimal, because while in a plastic condition the mass is subjected to such pressure that a mere trace remains, and yet sufficient to obtain proper adhesive qualities. From the beginning to the present improved processes and new machinery have been required.

Dr. James Bowstead Williams has carried on a long series of tests upon the comparative specific resistance of mica and micanite. The data and results are as follows:

The conditions of the tests were absolutely the same in all cases. The potential was constant, being over 3,000 volts. A dynamometer served to maintain the same pressure for different materials. All the samples were kept at the same temperature and under the same hygroscopic conditions for several days. Samples were of uniform thickness. The best samples of micanite gave approximately the same reading as the best India mica, indicating that the resistance of micanite is equal to that of the best commercial mica.

COST OF PREPARING CAUSTIC AND BLEACH BY THE ELECTROLYSIS OF SALT.

MANY processes have been proposed and tried, experimentally, for manufacturing caustic soda and bleach from common salt by electrolysis, but actual figures of the cost of such processes have never been ascertained, or at least published. The first time that impartial figures have been made public was in a communication to the Society of Chemical Industry, on December 5, 1892, by Messrs. Cross and Bevan. These chemists on that occasion gave a long account of the cost of the Le Sueur process, and, though the accuracy of some of the items is debatable, the estimate gives a sufficiently correct idea of the cost of the electrolysis of salt to make it worthy of record.

A plant to treat 18 tons of salt per day of 24 hours would comprise a pair of engines, each of 1,200 indicated horse power, dynamos and electrolyzing vats. The cost of maintaining this 2,400 indicated horse power, with coal at 10 shillings per gross ton, and depreciation at 10 per cent. per year on engines and boilers, would amount, on very liberal allowance, to £60 per 24 hours, or ¼d. per horse power hour. The loss from indicated horse power to electric power delivered at the terminals of the vats may be taken at 17 per cent., so that the effective horse power would be 2,000 horse power. This would give a current of 331,555 amperes at 4½ volts, and the available ampere hours in 24 hours for the work of decomposition would be 7,957,320. Each ampere hour is theoretically able to produce 0·00292 lb. of chlorine and 0·0033 lb. of caustic soda, so that with a possible efficiency of 80 per cent. in the operation, the actual daily output in this case would be 8·3 gross tons of chlorine, equal to 22·43 gross tons of bleach, and 9·378 gross tons of caustic soda. The bleach at £7 10s. per gross ton would bring £168, and the caustic soda at £12 per gross ton would have a value of £112 10s. The total value of the product would be £280 10s. The cost of production would be made up as follows: Power, 57,600 horse power hours, £60; 18 gross tons salt at 12s. per gross ton, £10 16s.; 12 gross tons of lime at 12s. per gross ton, £7 4s.; labor, £10; casks, packages, etc., £18; depreciation at 10 per cent. per year on electrolyzers, dynamos, tanks, pumps and buildings, £10; cost of renewal of diaphragms and anodes, £30; superintendence, £5; total, £151. In addition to this there is the interest on capital to be reckoned for and minor expenses, amounting altogether to another £10, probably. This would bring the expenditure per 24 hours to £161, as compared with £280 receipts. The cost of the plant would be about £50,000. The item for £30 per day for renewal of anodes and diaphragms seems extravagant. The diaphragms are composed of parchment paper and asbestos cemented together with coagulated blood albumen, and they require renewal every 48 hours. The anodes are composed of rough rods of gas carbon, and have to be renewed every six or eight weeks. What the total consumption of anodes and diaphragms in this plant is, is not given, but £30 per day must surely be a mistake.

THE MANUFACTURE OF LIQUORS AND PRESERVES.*

By J. DE BREVANS, Chief Chemist of the Municipal Laboratory of Paris.

CHAPTER III.

LIQUORS BY DISTILLATION.

LIQUORS by distillation are obtained from compound perfumed spirits, which are often prepared at the very moment of the manufacture of the liquor. The aromatic materials are cut, sliced, or pulverized, according to their nature, and are submitted to the same treatment as indicated under the head of "Essences" (page 14143). Macerate the materials in alcohol, add the water, and distill, then rectify with another quantity of water, and draw off the finished product. The distillation finished, the treatment with sirup follows, and the liquor is brought up to the desired strength, colored, and clarified. The sugar is always dissolved by heat in the requisite quantity of water, and the sirup is cooled before the mixture with the perfumed spirit. The rest of the water is then added.

FIG. 44.—ABSINTHE.

The general method of making liquors having been described, the principal receipts for the various liquors will be given.

Absinthe.

Grande Absinthe.

Small plant (Fig. 44), with a strong aromatic odor,

* Continued from page 14229, SUPPLEMENT No. 890.

taste very bitter, height about twenty inches, leaves white, soft to the touch, yellow flowers.

Ordinary Absinthe.
Absinthe Ordinaire.

Flowering tops and dried leaves of the greater absinthe	250 grm.
Hyssop tops and flowers, dried	50 grm.
Balm mint	50 grm.
Green anise	200 grm.

Macerate the materials, which have been lightly pounded, in a water bath with 5 l. 600 c. c. of alcohol (85°). At the end of 24 hours add 5 l. of water, and distill gently, so as to obtain 5 l. 60 c. c. of first quality liquor. Bring up to 10 l. at 46° by the addition of 4 l. 400 c. c. of water, color green with indigo blue, or, better, with chlorophyl. Allow it to repose and decant.

Absinthe (*Demi-fine*).

Greater absinthe, flowering tops and leaves	250 grm.
Lesser absinthe	100 grm.
Hyssop	50 grm.
Balm mint	50 grm.
Angelica roots	12 grm.
Green anise	400 grm.

Cut the materials fine, and macerate with 2 l. 500 c. c. of alcohol (85°). Distill after 24 hours with 2 l. of water. Draw off 2 l. 30 c. c. of good liquor, to which add 3 l. 500 c. c. of alcohol at 85° and 4 l. 200 c. c. of water to obtain 10 l. at 40°. Color as ordinary absinthe.

Absinthe (*Fine*).

Larger absinthe	250 grm.
Lesser absinthe	50 grm.
Hyssop	100 grm.
Balm mint	100 grm.
Green anise	500 grm.
Chinese anise	100 grm.
Fennel	200 grm.
Coriander	100 grm.

Macerate with 5 l. 500 c. c. of alcohol (85°). At the end of 24 hours add 2 l. 750 c. c. distilled water. Draw off 2 l. 750 c. c., add 2 l. 750 c. c. of alcohol at 85° and 2 l. of water to obtain 10 l. at 65°. Color green by the use of indigo blue, caramel, or, better, by chlorophyl.

Absinthe of Pontarlier.
Absinthe de Pontarlier.

Greater absinthe, dry and clean	250 grm.
Green anise	500 grm.
Fennel	500 grm.
Alcohol 85°	9 l. 500 c. c.

Macerate the plants in alcohol for 12 hours, and add 4 l. 500 c. c. of water before distilling. Draw off 9 l. 500 c. c. of perfumed spirits. Continue the operation until all the phlegm is drawn off, which is set aside for another operation.

The green color of the liquor is imparted by the following:

Small absinthe, dry and clean	100 grm.
Hyssop, dry tops and flowers	100 grm.
Balm mint (lemon balm)	50 grm.
Perfumed spirit from the previous operation	400 c. c.

The small absinthe is cut fine; the hyssop and the balm are powdered in a mortar, and the whole is digested by gentle heat with the spirit in a water bath. The heating operation terminated, the cooled liquid is passed through a haircloth sieve. To the colored liquor add 5 l. 500 c. c. of perfumed spirit, and reduce the strength to 74° by adding 500 c. c. of water, so as to obtain 10 l.

Absinthe of Montpellier.
Absinthe de Montpellier.

Large absinthe, dry	250 grm.
Green anise	600 grm.
Fennel	400 grm.
Coriander	100 grm.
Angelica seed	50 grm.
Alcohol (85°)	9 l. 500 c. c.

The process is the same as the above, and the coloration is produced by using the following plants:

Dried hyssop	75 grm.
Dried balm	75 grm.
Small absinthe	100 grm.

Absinthe of Lyons.
Absinthe de Lyon.

Large absinthe, dried	300 grm.
Green anise	800 grm.
Fennel	400 grm.
Angelica seeds	50 grm.
Alcohol (85°)	9 l. 500 c. c.

Coloring is made as follows:

Lemon balm	100 grm.
Small absinthe, dried	100 grm.
Hyssop dried with flowers	50 grm.
Dried veronica	50 grm.

Absinthe of Fougerolles.
Absinthe de Fougerolles.

Green anise	750 grm.
Fennel	410 grm.
Large absinthe, clean	260 grm.

The color is obtained from the following plants:

Lemon balm	75 grm.
Hyssop	60 grm.
Small absinthe	66 grm.
Veronica	66 grm.
Alcohol (85°)	9 l. 500 c. c.
Water	5 l.

Macerate in alcohol for 12 hours, add the water at the moment of distillation. Draw off 9 l. 500 c. c. Continue the distillation until all the phlegm has been distilled off. Reduce the strength of the liquid to 74°.

Absinthe of Besançon.
Absinthe de Besançon.

Large absinthe, cleaned	400 grm.
Green anise	500 grm.
Fennel	660 grm.
Coriander	66 grm.
Color with:	
Balm	50 grm.
Small absinthe	100 grm.
Hyssop	83 grm.
Alcohol (85°)	9 l. 500 c. c.
Water	5 l.

Same operation as above.

Absinthe of Nimes.
Absinthe de Nîmes.

Large absinthe, cleaned	366 grm.
Green anise	366 grm.
Fennel	250 grm.
Coriander	40 grm.
Roots black alder	25 grm.
Angelica root	25 grm.
Color with:	
Small absinthe	80 grm.
Hyssop	75 grm.
Balm (lemon)	25 grm.
Veronica	40 grm.
Mint	40 grm.
Alcohol (85°)	9 l. 500 c. c.
Water	5 l.

Same operation as given above.

Swiss White Absinthe.
Absinthe Suisse Blanche.

Large absinthe, cleaned	275 grm.
Small absinthe, clean	112 grm.
Hyssop flowers	110 grm.
Veronica	55 grm.
Genipi (*artemisia rupestris*)	55 grm.
Camomile	25 grm.
Green anise	525 grm.
Fennel (Florentine)	525 grm.
Coriander	100 grm.
Angelica seeds	55 grm.
Alcohol (85°)	9 l. 600 c. c.

Macerate the plants and proceed in the same manner as for green absinthe; reduce to 74°.

Vulnerable Elixir (Revulsive).
Elixir Vulnéraire Révulsif.

Take 100 grm. of the dry leaves of each of the following plants:

Absinthe	52 grm.
Angelica	52 grm.
Basilic	52 grm.
Calamint	52 grm.
Fennel	52 grm.
Hyssop	52 grm.
Lavender	52 grm.
Marjoram	52 grm.
Melilot	52 grm.
Balm	52 grm.
Mint	52 grm.
Origanum	52 grm.
Rosemary	52 grm.
Rue	52 grm.
Savory	52 grm.
Sage	52 grm.
Creeping thyme	52 grm.
Alcohol (85°)	5 l.
White sugar	2 k. 500 grm.

Distill and rectify twice. Bring the volume to 10 l. with water.

Human Balsam.
Baume Humain.

Balsam of Peru	15 grm.
Absinthe	15 grm.
Coriander	18 grm.
Acacia nuts	125 grm.
Peel of three lemons.	

Divide and break up the materials, mecerate for five days in 3 l. of alcohol (85°). Add 2 l. of water, and distill so as to obtain 3 l. Make a sirup with 1 k. 400 grm. of sugar and ¾ of a l. of alcohol, mix cold with the perfumed spirit. Color a light violet.

Swiss Formula for Same.

Large absinthe	1,000 grm.
Small absinthe	500 grm.
Angelica root	62 grm.
Sweet flag	62 grm.
Dittany (*Dictaine*)	15 grm.

Macerate for eight hours with 6 l. of alcohol (85°), and distill so as to obtain 5 l. Perfume with 4 grm. of essence of green anise. Color olive green.

German Formula.

Large absinthe	230 grm.
Angelica root	75 grm.
Green anise	375 grm.
Star anise	150 grm.
Fennel	375 grm.
Coriander	110 grm.

Macerate for 48 hours or less with 10 l. of alcohol at 60°. Distill slowly so as to draw off 7½ to 8 l. of the product, and make up to 10 l. at 75° with 90° alcohol. Color green.

Cream of Absinthe.
Crème d'Absinthe.

Leaves and flowering tops of large absinthe	250 grm.
Small absinthe	60 grm.
Peppermint, dry leaves	60 grm.
Green anise	60 grm.
Fennel	25 grm.
Sweet flag	15 grm.
Skins of two lemons.	

Macerate for two days in 4 l. of alcohol (85°), add 3 l. 500 c. c. of water, and draw off 3 l. 800 c. c., add a cold sirup made with 5 k. 500 grm. of sugar and 2 l. 500 c. c. of water. Dissolve with heat. Bring up to 10 l. with water, color green and filter.

Amber Seed.
Huile des Créoles.

Musk	12·5 grm.
Cloves	12·5 grm.
Amber seed	50 grm.
Alcohol (85°)	4 l.
White sugar	5 k. 500 grm.

Usual method. Do not rectify. Raise to 10 l., color with cochineal.

Angelica.
Angélique.

The roots and twigs of the angelica (Fig. 45) have a

FIG. 45.—ANGELICA ROOT.

musk-like odor, vermicular root, height three to six feet, leaves large, green, and white, flowers greenish yellow.

Cream of Angelica.
Crème d'Angélique.

Angelica roots	130 grm.
Angelica seeds	125 grm.
Fennel	12 grm.
Coriander	15 grm.

Same method as for *crème d'absinthe.*

Green Anise.
Anis Vert.

Annual plant (Fig. 46) has many branches, flowers

FIG. 46.—GREEN ANISE.

white to red, fruit green, ovoid and striated, of strong odor, stinging taste.

Oil of Anise.
Huile d'Anis.

Green anise	200 grm.
Cacarilla (wood)	50 grm.
Rosewood	50 grm.

Macerate for 24 hours in 4 l. of alcohol (85°), after having crushed and rasped the wood and the seeds. Distill with 2 l. of water so as to draw off 4 l. Add, when cold, a sirup made with 5 k. 1,500 grm of sugar in 2 l. 500 c c. of water. Color red with cochineal.

(To be continued.)

WHAT ARE LINES OF FORCE?

THE mathematical methods and hypotheses of the French school of physicists, represented chiefly by Ampere, Arago, Poisson and Coulomb, consisted in the assumption that material particles in special states, called electric and magnetic, could act on one another at finite distances without any intervening mechanism according to certain laws of force varying with the distance. Faraday may be said to have raised the stand-

ard of revolt against this notion, and indeed he was able to quote in his support the great authority of Newton in rejecting the idea that matter could act on matter across intervening distance without aid from any mechanism. He never considers bodies as existing with nothing between them but their distance, and acting on one another according to some function of that distance. He conceives all space as a field of force, the lines of force being in general curved, and those due to any body extending from it on all sides, their direction being modified by the presence of other bodies. A magnet, an electrified conductor, or a wire conveying an electric current, are thus the focus and originators of a system of radiations of force lines or loops, which are to be thought of as part and parcel of it. This force system is capable of deformation or change by the presence of other bodies, but it moves with the magnet, electrified body, or current-carrying wire. These force radiations penetrate surrounding bodies, and the apparent actions between bodies at a distance are in reality actions due to immediate action of the field of force of one body upon the other at the place where it is. Then rises for solution the important problem: What *are* these lines of force? Faraday answered the question by saying that they consist in some sort of operation or action going on in a *medium* along certain lines or axes, and Maxwell added to this the suggestion that the electromagnetic medium must be identical with the medium postulated to account for the phenomena of light.—*Electrical Age.*

THE MAHOMETAN BUCKRA EDE FESTIVAL.

OUR illustrations, for which we are indebted to the *Graphic*, London, represent two groups of over a thousand Mahometans at the prayer festival called Buckra Ede during its celebration at Naini Tal in the Northwest Provinces of India. The Buckra Ede Festival is one of the most important of the Mahometan year. The Buckra Ede, or, more correctly, the Baqr-i-id, the Cow Festival, is identical with the Id-ul-Azha (vulg. Id-uz-Zoha), the Feast of Sacrifice, which is held on the 10th day of Zul Hijja, and which forms the concluding scene of the Mecca pilgrimage. It is also known by several other Arabic names signifying the Great Feast.

Although later commentators have identified this sacrifice with the one contemplated by Abraham in Jewish history, the origin seems to have been merely the recognition that the shedding of blood must be an essential feature of the remission of sin, and in the Mahometan rite either a cow or a sheep, a goat or a camel may be slaughtered, provided that it is without blemish. Jellaluddin Suyty is the first Mahometan commentator who declared that the festival was instituted in commemoration of Abraham's willingness to sacrifice his son Ishmael—the Isaac of the Bible. He states that "when Ibrahim (the power of God be upon him!) founded Mahometanism the Lord desired him to prepare a feast for him. Upon Ibrahim (the friend of God!) requesting to know what he would have on the occasion, the Lord replied, 'Offer up thy son Ismail.'" A more vulgar version is to the effect that Ibrahim, being a good man, was called upon to make a sacrifice. He first made one of a camel, the next morning one of a horse, the next a goat, and so on for one hundred mornings. Still God said he must bring his best beloved object, when he brought his son Ishmael. At Mecca, and in India it follows the same lines, the sacrifice is performed as follows. The people assemble for prayer at the Idgah as on the Id-ul-Fitr (*i. e.*, the feast of breaking fast, or the lesser festival, which forms the penultimate stage of the Mecca pilgrimage). After prayers the people return to their houses. The head of the family then takes a sheep, or a cow, or a camel to the entrance of the house, and sacrifices it by repeating the words, "In the name of the great God," and cutting its throat. The flesh of the cow or other animal is then divided, two-thirds of it being retained by the family and one-third going to the poor in the name of God. One of the most remarkable Hadis recognized by the world of Islam has special reference to this feast. It runs as follows: "Man hath not done anything on the Id-ul-Azha more pleasing to God than spilling blood, for verily the animal sacrificed will come on the day of resurrection with its horns, its hair, and its hoofs, and will make the scales of his (good) actions heavy. Verily its blood reacheth the acceptance of God before it falleth upon the ground, therefore be joyful in it." The Buckra Ede Festival is celebrated throughout Mahometan India with not less fervor than by the devoted pilgrims to Mecca. A certain number of the audience or congregation have performed the pilgrimage themselves, and they set an example of religious fervor to those who have not been so fortunate. The Buckra Ede Festival has a special interest for Europeans, in that it is the nearest resemblance in Mahometanism to the Christian doctrine of the Atonement, and bears a still more striking similitude to the sacrifices in the Old Testament. Our illustrations are from photographs by Fry and Rahn, Naini Tal, India.

A GROUP OF MAHOMETANS AT THE BUCKRA EDE FESTIVAL, INDIA.

JAPANESE CAMPHOR.

THE following particulars respecting the Japanese camphor trade are extracted from a recent report by the United States consul at Osaka:

The camphor tree, from which the resinous gum is distilled, is a species of the laurel, and is found in the provinces of Tosa, Hiuga, and Satsuma, in the south of Japan. Large groves of the trees are owned by the Japanese government, the wood being very desirable for shipbuilding. The districts in which the camphor tree is found are mountainous and situated far from the sea. No reliable information can be obtained as to the cost of producing the gum before being transported in junks to Hiogo. The peasants who engage in distilling the roots and branches of the trees are said to be poor, and employ the rudest machinery.

The market value of crude camphor gum and of oil of camphor per picul (133⅓ lb.) during the past year was as follows: Drained, $38.25; wet, $37; old dry, $43.50; average, $36.50; camphor oil, $5.25.

The highest and lowest prices during the same period were as follows: Highest, $40; lowest, $33.

Camphor gum is exported in tubs measuring about 6½ cubic feet; oil, in kerosene tins and cases. The grades are from old dry down to new wet, and the various grades depend upon the quantity of adulteration. In oil there are two grades—white and brown.

Adulteration is practiced for the most part by adding water and oil just as far as the buyer will tolerate. In some cases 20 lb. of water will run out of a tub in twelve hours. The unadulterated article, known as the good old dry, can sometimes be bought. The only

MAHOMETANS IN PRAYER AT THE BUCKRA EDE FESTIVAL, INDIA.

THE GREAT MAHOMETAN FESTIVAL OF THE BUCKRA EDE, OR BAQR-I-ID, AT NAINI TAL, IN THE NORTHWEST PROVINCES OF INDIA.

system of tests in determining value of the different qualities is by burning and by absolute spirit. The percentage of pure camphor which the crude yields when refined varies according to the quality of the crude. The average percentage of gum produced from the wood as compared with the original weight of the wood cannot be accurately ascertained here, the only foreigner known to have visited the camphor districts having declined to furnish any information on the subject.

The total exports of camphor from Hiogo during 1891 in catties of 1⅓ lb. each amounted to 3,850,400 catties, consigned to the following destinations: Europe (countries not specified), 1,777,300 catties; London, 335,600 catties; Germany, 209,200 catties; United States, 1,277,000 catties; China, 51,900 catties; France, 199,400 catties.

As regards the manufacture of camphor, the following particulars are extracted from a report by the United States consul at Nagasaki:

Camphor is found alike on high elevations and in the valleys and lowlands. It is a hardy, vigorous, long-lived tree, and flourishes in all situations.

Many of these trees attain an enormous size. There are a number in the vicinity of Nagasaki which measure 10 and 12 feet in diameter. The ancient temple of Osuwa, at Nagasaki, is situated in a magnificent grove of many hundred grand old camphor trees, which are of great age and size, and are still beautiful and vigorous. It is stated that there are trees at other places in Kiu Shiu measuring as much as 20 feet in diameter. The body or trunk of the tree usually runs up 20 and 30 feet without limbs, then branching out in all directions, forming a well-proportioned, beautiful tree, ever green and very ornamental.

The leaf is small, elliptical in shape, slightly serrated, and of a vivid dark-green color all the year round, except for a week or two in early spring, when the young leaves are of a delicate, tender green. The seeds or berries grow in clusters, and resemble black currants in size and appearance. The wood is used for many purposes, its fine grain rendering it especially valuable for cabinet work, while it is used also for shipbuilding. The roots make excellent knees for ships.

In the manufacture of camphor the tree is necessarily destroyed, but, by a stringent law of the land, another is planted in its stead. The simple method of manufacture employed by the natives is as follows:

The tree is felled to the earth and cut into small pieces, or, more properly speaking, into chips.

A large metal pot is partially filled with water and placed over a slow fire. A wooden tub is fitted to the top of the pot, and the chips of camphor wood are placed in this. The bottom of the tub is perforated so as to permit the steam to pass up among the chips.

A steam-tight cover is fitted on the tub. From this tub a bamboo pipe leads to another tub, through which the inclosed steam, the generated camphor and oil flow. This second tub is connected in like manner with a third. The third tub is divided into two compartments, one above the other, the dividing floor being perforated with small holes, to allow the water and oil to pass to the lower compartment. The upper compartment is supplied with a layer of straw, which catches and holds the camphor in crystal in deposit as it passes to the cooling process. The camphor is then separated from the straw, packed in wooden tubs of 133⅓ lb. each, and is ready for market.

After each boiling the water runs off through a faucet, leaving the oil, which is used by the natives for illuminating and other purposes.

THE WORLD'S FAIR.

RULES GOVERNING THE SUPPLY OF LIGHTING AND POWER TO EXHIBITORS IN THE DEPARTMENT OF ELECTRICITY.

ELECTRIC power only will be supplied in the electrical building.

The aisles of the building will be illuminated with arc lamps without cost to exhibitors; additional lighting to be paid for by exhibitors at the following rates:

Arc lamps, service May 1 to October 31, 1893, during exposition hours, $65.00 per lamp of 2,000 nominal candle power. Lamps suspended from ceiling with opal globes and globe nets; special fixtures or globes, or special ornamental lamps, will be subject to an extra charge to be fixed by the director-general and the director of works.

Incandescent lamps, service May 1 to October 31, inclusive, 1893, during the hours of the exposition, $8 per 16 candle power lamp, including installation of first lamp and socket and lamp renewals. Breakages must be purchased by exhibitor of the contractor lighting his space, at the usual commercial rate. Lamps will be hung on plain cord or pendant. Special or fancy wiring will be furnished at an extra charge to be fixed by the director-general and the director of works. Fixtures and shades will be furnished and maintained by consumer. Special colored or fancy lamps, or lamps other than 16 candle power, will be subject to special agreement with the director-general and approved by the director of works. Installations of 300 lamps or more will be subject to special discount to be fixed by the director-general.

MOTORS.—Exhibitors requiring motive power will furnish necessary motors, rheostats, main line switches, insulating base, etc., complete, together with all belts, countershafting, and other means of connecting motors to operating machinery. Motors should be suitable for operation on the class of circuit furnished in exhibitor's location.

The rheostats must be constructed wholly of noncombustible material. The main line switch shall be of the knifeblade type, of ample carrying capacity, and suitable for breaking current at the potential used. Motors shall be erected in position at the expense of the exhibitor by the contractor furnishing power in the location of his exhibit, service connections to motors being installed, maintained and owned by the said contractor.

Charges for service connections with the main line will be as follows:

For one-half horse power and less, $8.

For one horse power to five horse power, per horse power, $12.

For more than five horse power and not exceeding ten horse power, per horse power, $10.

For more than ten horse power, per horse power, $8.

Fractions of a horse power will not be considered, except for motors of less than one horse power.

Ratings of motors will be the standard rating of the manufacturer.

Charges for service will be based on the maximum electrical horse power delivered to the motor, irrespective of the class of work to be operated by the motor, at the following rates:

For ¼ horse power and less, $15.

For more than ¼ horse power, and not exceeding ½ horse power, $20.

For more than ½ horse power, and not exceeding one horse power, $30.

For more than one horse power, and not exceeding two horse power, per horse power, $45.

For more than two horse power, and not exceeding three horse power, per horse power, $42.50.

For more than three horse power, per horse power, $40.

A limited amount of power may be furnished to exhibitors free of charge to simply turn over an otherwise inoperative exhibit.

LIFE SAVING DEVICE FOR WELLS.

THE illustrations represent a simple and durable appliance for preventing the accidental drowning or suicide of persons in wells, which has been invented by Mr. Rutnagur, of the *Indian Textile Journal*, and which has obtained the approval of the Royal Humane Society of Great Britain. This gentleman has been induced to devise this appliance owing to the large number of suicides which annually take place in Bombay,

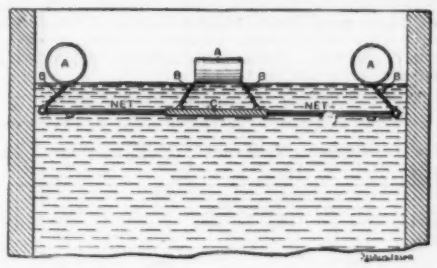


FIG. 1.—PART SECTIONAL ELEVATION OF WELL.

it being stated that there is scarcely a well in the city that has not, at some time, been used for this purpose. As will be seen the appliance consists of a hoop of wood or metal, over which is stretched a net of light tarred rope with 4 in. meshes. The hoop is about 1 ft. less in diameter than the interior of the well, and to it are attached three or more closed metallic drums, A, serving as floats, which hold, by means of chains, B, the net at the desired distance below the surface of the water, allowing ordinary vessels to be filled above it. The buoyancy of the drums is equal to carrying at least two persons on the netting—the one who attempts to commit suicide and the person who may go to his assistance. In wells containing a Persian wheel, a gap is made in the net for the passage of the buckets. The hoop of the net is in this case kept in position as regards the buckets by a vertical guide bar of wood fixed against each side of the well. In large wells a circular

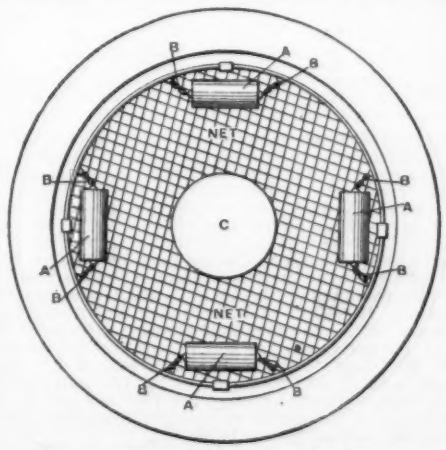


FIG. 2.—GENERAL PLAN OF WELL.

floating platform or ring, C, may be used to support the middle of the net. The net, with its fitting, is an independent structure resting in the water, and rising and falling with the alteration of level of water in the well.

THE CANARY ISLANDS.

THE latest Foreign Office report on Spain contains a comprehensive pamphlet on the social and economical conditions of the Canary Islands, by Mr. Samler Brown. About 1490 the Canaries were partly planted with sugar and large profits realized, until, in the sixteenth century, the islands were unable longer to compete with the West Indies. Recently a fresh start has been made by means of British capital; and now there are several steam factories in Grand Canary and one in Teneriffe. From 1490 to 1850 the vine throve on the islands, but at the latter date it was destroyed by the ravages of a fungus; the European had to be replaced by American vines, and the quality of wine has greatly deteriorated. The trade, however, has rapidly revived since 1885, and the vine will probably again become the most important of all the products of the country. Cochineal was originally brought to the Canaries in 1826, and after some prejudice had been overcome it was found that the dye was produced more plentifully and of better quality than in other countries. The discovery of aniline dyes brought about a crisis, and the export of cochineal has rapidly decreased. The attempt to replace cochineal by tobacco has proved a failure. The land is now largely planted with tomatoes, bananas, and oranges, and the Canaries are becoming a market garden for Northern Europe, earlier by several weeks than the Channel Islands. The steepness with which the coast lands rise upward to the hills occasions a succession of zones differing in temperature, nature of soil, and other conditions. There are five climatic zones, the limit of cultivation rarely exceeding 4,000 ft. The forest land begins at an elevation of about 3,000 ft., and the greatest height at which any shrub is found is about 11,000 feet. The Spanish government has ordered the planting of young trees and prohibited the previous reckless waste. There is no record of freezing point being touched at Laguna, 1,840 ft., the highest point at which regular meteorological observations have been taken for a series of years. At Vila Flor, 4,335 ft., the lowest temperature recorded was 28°. The highest summer record was 104° at Laguna; the ordinary summer temperature in towns by the sea averages 82°. The annual rainfall at Las Palmas is 8·35 in., in Zaguna 29·41. In the western islands droughts are unusual, but in the eastern, specially in Fuerteventura, great distress is occasioned. The islands of Hierro and Fuerteventura have no springs, and Langarote has very few. These depend simply on the dew and rainfall. Grand Canary possesses by far the best water supply; Teneriffe could profitably use for irrigation ten times as much water as is available. The water is carried from the springs in water courses of stone, and by evaporation, leakage, or robbery, a large percentage is lost. An estimate for 1869 states that all the cultivated land, including woods, vineyards, and pasturage, amounted to 845 square miles; in 1890 the total amount of irrigated land in Teneriffe and Grand Canary was 15,000 acres. The deep water between the shallow banks on the West African coast and the Canary Islands affords one of the best fishing grounds in the world. The kind of cod caught is said to be superior to that got on the Newfoundland bank; while there are tunny, porpoises, seabream, and many other species of fish. The fisheries have never been properly worked, and are now carried on in a very half-hearted fashion.—*Journal R. G. S.*

ON CHOLERA, WITH REFERENCE TO THE RECENT EPIDEMIC AT HAMBURG.

By Privy Councilor VON PETTENKOFER.*

THE outbreak of cholera in Hamburg in August, 1892, naturally excited all Germany. The alarm—which the explosive occurrence of the disease in the chief commercial city of Germany, hitherto regarded as the type of a rational drainage system—spread throughout Europe and beyond it, and was not less than that of sixty years ago, when cholera first advanced into Russia from Asia. It is excusable that in 1892, as in 1831, physicians and governing bodies thought first of all how to prevent the further progress of the destroying angel—how to localize it at Hamburg.

The rigid regulations in force throughout Germany to insure this limitation may be compared with the military cordons and other measures of detention and isolation in vogue sixty years ago. They are based on the belief that cholera is simply an infectious or contagious disease, passing from the sick and their excreta to the healthy; and that the virus can only be taken with the food, and especially in water. This is now deemed to be absolutely proved since Professor R. Koch made his interesting and scientifically valuable discovery that the evacuations of cholera invariably contain the comma bacillus. The question is now limited to determining how this bacillus acts, how it may be destroyed and how its diffusion may be prevented. The strife against the bacillus is by most now deemed to be the only real prophylaxis, to the ignoring of the great mass of epidemiological facts which are entirely opposed to the mere contagionist view of cholera. Many confine themselves to the behavior of comma bacilli in test tube or plate and do not trouble themselves at all about the behavior of cholera in its epidemic extension. Many years ago I said that the etiology of cholera appeared to me as an equation with three unknown quantities—x, y, and z. Let x be a specific germ disseminated by human intercourse; y something which depends on place or time, the "local disposition;" and z the individual disposition met with in all infectious diseases, both the directly infectious, as syphilis and small-pox, and others, as typhoid fever and malaria. The contagionists have eliminated the y, finding a sufficient explanation in Koch's discovery of the x, and seeing in individual tendency or absence of immunity the factor z; so that if z be granted, cholera must occur should people introduce the bacilli into the mouth by unwashed hands, or take them into the stomach with water and food. The view is simple and easy, sufficient for him who only concerns himself with individual cases, but it does not satisfy the epidemiologist; for the latter knows that there are not only cholera-immune people, but also cholera-immune places, and that even in places where cholera has prevailed there are seasons when it will not spread, although introduced. This is what I mean by the y. It is not so easy to define as is the x, and so far one can only say that it is related to the quality and dampness of soil; but it is going too far to assert, as some do, that Koch's comma bacillus is an unimportant, if constant, concomitant.

Man alone of all living creatures is susceptible to the cholera virus, and therefore experiments on animals with comma bacilli can determine nothing. The effects on the guinea pig—previously prepared by the administration of soda solution—of an injection of a culture of bacilli, followed by one of laudanum, or the results of the intra-peritoneal injection of fresh cultures, are of no manifest importance as against the fact, confirmed a thousand times, that epidemics of cholera are never accompanied by epizootics. Now and then it has been noted that cholera has coincided with undue fatality among cats or poultry, but the association has been purely accidental. Guinea pigs did not suffer during the late outbreak at Hamburg.

* Abstract of a paper contributed by Prof. Von Pettenkofer to the Munchener Medicinische Wochenschrift, Nov. 15, 1892. Reproduced from the *Lancet*, London, Nov. 19, 1892.

Similar experiments on animals with non-pathogenic fungi—*e. g.*, the bacterium coli commune—are fatal, and the bacteria multiply in the body just like the comma bacilli. So that the only indisputable experiments on infection with comma bacilli are those made on man. The invariable presence of comma bacilli in cholera stools proves that the fungus has something to do with cholera, but it is still a question whether it alone causes the disease and solely generates the virus. According to my localistic notions it cannot do this in places which are permanently immune from cholera, nor in places which, if occasionally susceptible, are yet at that time not disposed for cholera.

Now as Munich, in the year of grace 1892, in spite of much travel of persons from Hamburg and Paris, and in spite of its October fair, remained free from cholera, I did not scruple to experiment on myself with the comma bacillus. Of it I had received from Hamburg, through my colleague, Dr. Gaffky, a pure agar culture, and from this my junior colleagues, Drs. Pfeiffer and Eisenlohr, prepared a sufficient quantity of broth culture to be taken by the mouth. As Gruber found that fresh cultures acted on guinea pigs more powerfully than cultures several days old, I employed a broth culture which had been in the incubator barely twenty-four hours. One cubic centimeter of this was found to contain innumerable bacilli, after being diluted a thousandfold, so that I could take at one dose milliards of bacilli, very many more than one could possibly introduce by unwashed hands. Since Koch states that comma bacilli are destroyed by the acid of the gastric juice, I was careful to take them on an empty stomach —viz., two hours and a quarter after my "fruhstuck" —when, according to my friend the physiologist, Carl von Voit, there would not be more than 100 cubic centimeters of gastric juice with 0·2 per cent. of hydrochloric acid in the stomach. To neutralize this free acid the broth culture of bacilli (1 cubic centimeter) was taken in 100 cubic centimeters of water, containing 1 gramme of bicarbonate of soda. The vessel was afterward rinsed with 50 cubic centimeters of water, so as to insure my taking all the bacilli. I drank this cholera mixture in the presence of witnesses on Oct. 7, it tasting like very pure water. Some were anxious about me, and begged that I would allow them to sacrifice themselves for their old teacher, but I wished to act on the old medical principle, *fiat experimentum in corpore vili*. I was right in regarding myself as a *corpus vile*. I am seventy-four years old, have had glycosuria for years, have not a single tooth in my head, and only use my artificial teeth when I have to make a speech, not needing them for mastication; and I also feel other burdens of advancing age. Even if I had deceived myself and the experiment had endangered my life, I should face death calmly, for it would not be as a thoughtless or cowardly suicide. I should die in the cause of science, like a soldier on the field of honor. Health and life, as I have often said, are very great earthly gifts, but not the highest. He who wishes to rank higher than the brute must be ready to sacrifice even life and health for great ideals. However, to me the matter did not seem quite so tragic, for I was firmly convinced my *x* could not kill without my *y*.

[Professor Von Pettenkofer then gives a detailed account of his condition, *de die in diem*, as to temperature, pulse, sleep, food, intestinal symptoms, etc. On the 9th he began to have diarrhœa, and did not feel very well, having some abdominal discomfort; the diarrhœa increased on the 10th and continued up to the 14th. He took no medicine to control the diarrhœa, although advised to do so, lest it should become chronic.]

The motions were examined bacteriologically by Drs. Pfeiffer and Eisenlohr to trace the fate of the comma bacilli. The first loose motion contained a large quantity, and the subsequent watery stools contained pure cultures of the bacilli. On Oct. 14, there were only a few isolated bacilli, and by the 16th these had disappeared. Bacteriologists generally admit that comma bacilli do not excite cholera by invading the body from the bowel, but that, remaining in the intestine, they give rise to the virus, which is absorbed, and then causes choleraic symptoms. Virchow more than twenty years ago pointed out the resemblance of cholera to acute arsenical poisoning. How great must have been the amount of poison formed by the many milliards of comma bacilli during their eight days' sojourn in my intestine! But I did not suffer at all from poisoning, was quite well, retained my appetite, had no trace of nausea, no fall of temperature, no albumen in the urine, etc., and went about my daily avocations, so that I could not but conclude that, although comma bacilli may cause diarrhœa, they cannot cause cholera, either European or Asiatic. Possibly in Hamburg my experiment might have ended fatally, because there, on Oct. 7, in addition to the Asiatic *x* there was plenty of the Hamburg *y* present, and it might have been that a much smaller dose would have excited severe cholera.

[When this experiment had terminated another was made in the person of Professor Emmerich, conducted on the same lines, except that he took a more restricted diet. A similar record is given of the daily condition in this case, the experiment commencing on October 17th. Early next morning there was one fluid motion, and in the course of the day diarrhœa set in, so that on the 19th to 20th there were as many as fifteen to twenty colorless, watery evacuations, and an enema containing tincture of thebaica was administered, and on the 20th one of tannic acid and opium. The motions became natural in the course of the 21st. Comma bacilli were found in the stools from October 18th to the 28th, the motions on the 19th being almost pure cultures. On the 24th Professor Emmerich returned to his usual diet. Throughout his general condition was undisturbed, appetite retained, no pain in abdomen and only some weakness from the diarrhœa. Apart from the diarrhœa he had some hoarseness of voice and dryness of pharynx.]

These two experiments on man show that the comma bacillus does not generate the virus of Asiatic cholera, thus confirming Bouchard's results of the different effects of injections into animals of pure cultures and of the excreta (stools and urine) from cholera patients. Choleraic symptoms were not induced by the former, but only by the latter. Bouchardi's experiments also show that the special cholera poison is only formed in the human organism. Perhaps one should concede that Emmerich and I did have a mild attack of cholera, as Koch and his numerous supporters would say, but I cannot admit the correctness of their view of the sufficiency of *x* and *z* to cause an epidemic, to the exclusion of *y*, no more than I can agree to the regulations enforced in Germany, Austria-Hungary and Italy, based on the discovery of the comma bacillus. Yet Dr. Baur and Dr. von Ziemssen, who have had large experience of cholera, affirm that the symptoms we exhibited were not those of which they had experience in cholera epidemics. According to the contagionist practice, on the discovery of comma bacilli in my evacuations, I ought to have been ruthlessly confined in the isolation barracks of Munich and my dwelling thorough disinfected. It seems a pity that this did not take place, for if it had, the contagionists would have been able to have loudly proclaimed that they had saved Munich from cholera, since Emmerich and I, by our stools, which were discharged without disinfection into the closets and drains, might otherwise have certainly infected the town. Joking apart, I too would become a contagionist, so comforting and so sparing of all further trouble is the view, if it could only be explained to me why so many places into which cholera has repeatedly entered have never had an epidemic. Lyons, which stands on the direct line of traffic between Paris and Marseilles, two infected foci, is a striking instance. Koch's explanation of this from the practice of washing linen on ships in the fast flowing Rhone and Saone can hardly apply, since a like practice obtains at Zurich and Stuttgart, which do not enjoy such an immunity. The contagionists neither attack nor dispute the epidemiological facts which I have published on this head; they only ignore them, for they harmonize so little with contagionist theory.

Since 1831 Hamburg has been visited by cholera fifteen times and Berlin twelve times (Table I.) The traffic by land and water between the two cities is extremely intimate, giving every chance for the transference of comma bacilli.

TABLE I.—CHOLERA IN BERLIN.

Year.	Commenced.	Terminated.	Population.	Deaths.	P. r 1000
1831	Aug. 30	Jan. 26, 1832	229,843	1423	6·2
1832	June 17	Mar. 14, 1833	234,171	412	1·8
1837	Aug. 11	Dec. 6	265,394	2308	8·8
1848	July 27	" 9	400,557	1395	3·9
1849	May 30	" 11	401,802	3522	8·8
1850	Aug. 6	Nov. 24	405,737	711	1·8
1852	Sept. 4	Dec. 31	413,517	165	0·4
1853	Aug. 7	Nov. 30	415,425	940	2·3
1854	—	—	—	—	—
1855	July 26	Nov. 26	419,241	1385	3·3
1856	—	—	—	—	—
1857	—	—	—	—	—
1859	—	—	—	—	—
1866	June 14	Nov. 17	658,251	5457	8·3
1871	Aug. 14	" 3	826,341	55	0·07
1873	July 21	" 7	918,841	740	0·8

CHOLERA IN HAMBURG.

Year.	Commenced.	Terminated.	Population.	Deaths.	Per 1000
1831	Oct. 31	Jan. 10, 1832	145,363	476	3·2
1832	Feb. 2	Dec. 17	146,365	1459	10·2
1837	—	—	—	—	—
1848	Sept. 1	Dec. 31	167,291	1674	10·0
1849	June 14	Nov. 22	168,061	563	3·3
1850	July 26	Jan. 11, 1851	171,013	400	2·3
1852	—	—	—	—	—
1853	June 23	Oct. 29	182,534	244	1·3
1854	" 14	Nov. 14	284,274	281	1·5
1855	" 30	Oct. 22	185,641	175	0·9
1856	" 15	Nov. 14	187,806	67	0·3
1857	" 9	" 27	191,910	463	2·4
1859	" 9	Oct. 5	196,747	1109	5·6
1866	" 30	" 22	214,174	1093	5·1
1871	Aug. 1	Sept. 24	325,332	141	0·4
1873	June 14	Nov. 8	348,127	1001	2·9

The lack of correspondence as to time, severity of the outbreaks in the two places, is notable, especially in the years 1831, 1837, 1848 and 1849. Again, since 1831 neither of these towns has had a winter epidemic, whereas in Munich two out of the three outbreaks during the same period have been in the winter—viz., 1836-37, 1873-74. The seasonal variations in cholera are well shown in the statistics compiled by Brauser from all cases occurring in the kingdom of Prussia from 1848 to 1859, the numbers being grouped in semi-monthly periods. He found that the minimum of cases and deaths fell in the first half of April, the totals being for these twelve years 71 and 50 respectively; while in the first half of September they mounted to 57,395 cases and 31,048 deaths. Taking the half monthly minimum of deaths as unity, the rise and fall in the incidence of the disease, as gathered from these statistics, may be thus given (Table II.):

TABLE II.

Date.		Relative mortality.	Date.		Relative mortality.
April	1-15	1·0	October	1-15	389·2
"	16-30	1·2	"	16-31	316·1
May	1-15	2·2	November	1-15	227·2
"	16-31	6·7	"	16-30	125·3
June	1-15	39·2	December	1-15	84·9
"	16-30	48·9	"	16-31	60·1
July	1-15	61·0	January	1-15	28·5
"	16-31	108·6	"	16-31	17·8
August	1-15	253·4	February	1-15	10·2
"	16-31	439·2	"	16-28	6·6
September	1-15	650·9	March	1-15	3·3
"	16-30	510·2	"	16-31	1·1

How is it possible to account for this enormous rise from 1 to 620, according to season, by the properties of the comma bacillus? Why does the bacillus act so powerfully in Hamburg and Berlin at one epidemic and so feebly at another? There must be a seasonal influence: What is it?

Some think it is due to *temperature*, but although in Hamburg and Berlin epidemics generally begin in June and end in November, less often in October or December, yet there have been severe winter epidemics in Moscow, St. Petersburg, Munich and elsewhere. In Calcutta, where it is endemic, the minimum of cholera is in August or September, the maximum from January to April, mostly April, and the mean temperature in Calcutta in April is 30° C., of August 28° C.—*i. e.*, is nearly equal. But if the comma bacilli simply pass from man to man, season should have no influence, for the temperature of the intestine is constant at 37·5° C.—a tropical climate. There is, however, at Calcutta, another climatic factor—viz., the *rainfall*—which in April has a mean of 60 millimeters and in August of 365 millimeters, the annual average being 1,600 millimeters unequally distributed throughout the year. The rains begin in May and end at the end of September or October, the remaining months passing, perhaps, without a drop of rain. Now the monthly mortality of cholera forms a curve exactly inverse to that formed by the rainfall. Rain can hardly affect bacteria, especially comma bacilli, which flourish in moisture and are destroyed by dryness. In Prussia the same correspondence between rainfall and cholera holds, and perhaps the cause of the winter outbreaks at Munich may similarly be explained. The 1873 epidemic in Munich bears this out. It began suddenly in August and as rapidly declined, so that very few cases occurred during October, although at this time there was much movement of the population (changing houses, opening of schools, etc.) At the commencement of November it broke out again, and by December 4 it had reached a height of 56 cases daily, whereas in the whole of October there were only 21 cases reported.

Inexplicable on the bacillary contagionist view, it can be readily explained from the localist standpoint. The germ *x* was present in Munich long before the first case occurred. It is an epidemiological fact that cholera in certain places in India and beyond India may remain quiescent for months and then break out again, while even longer periods of quiescence must be admitted for the outbreaks in Hamburg, Berlin and Munich.

In the summer of 1868, at Bellinghausen, in Essen and elsewhere in the Prussian Rhine provinces, and in Westphalia, there were cholera epidemics, but nowhere else in Europe; and unless its auctothonous origin be accepted, these outbreaks must be referred to the residues of the epidemic of 1866, which had been dormant in Essen. The great epidemic in Egypt in 1883 did not affect the Mediterranean ports that year. France saw in this the efficacy of quarantine, but in 1884 it broke out in that country. So in July and August, 1873, the local outbreak in Munich occurred after a very dry July, and was checked by an exceptionally wet August, but reappeared in the winter during another abnormally dry season.

It is remarkable that in Augsburg, which suffered so severely in 1854, and into which, in 1873, cases were introduced from Munich, no epidemic occurred in that year. This was not due to disinfection—it was before the discovery of the comma bacillus—but more likely to the excessive rains with which Augsburg was visited in 1873.

There is no doubt that like atmospheric conditions played a part in the epidemic at Hamburg last year. The summer had been exceptionally dry and hot; the heat in August was almost unbearable, being about 5° above the average, while the rainfall in July, August and September was considerably below the mean:

	1892.	Mean rainfall.
July	21 mm.	97 mm.
August	53 "	77 "
September	46 "	64 "
	120 mm.	238 mm.

Naturally also the level of the subsoil water was lowered. The temperature of the Elbe, which is taken in mid-stream every morning, rose in August to 22° C. Yet similar conditions of weather prevailed in other parts of North Germany, which were also susceptible to cholera, but where it has not yet become epidemic, and where probably epidemics will break out shortly. As regards the rainfall, only those places can be compared where observations have been continuous, for, as at Munich and Augsburg, neighboring districts where the average rainfall is the same may differ very widely in particular years and seasons. The cholera germ from Russia has been more widely disseminated this year in France than in Germany, and that it only found a favorable soil in Hamburg must be due to a special reason.

Hamburg for years has been making a special hygienic experiment on the largest scale, for it thinks that it can be cleansed by using an extremely impure water. The Hamburg water works distribute unfiltered Elbe water throughout the town and suburbs. In the mains are found dense layers of fungi of vegetable and animal origin; here and there a tap is plugged by the head of an eel. For drinking purposes the water may be filtered at home, or if this does not suffice, thirst may be quenched by wine, beer, seltzer, etc. For all domestic uses, for cleansing rooms and dwellings, courts and streets, the unfiltered Elbe water is alone used, and then, owing to the excellent drainage into the Elbe, part of the refuse of the city must actually flow back into the water mains, thus rendering nugatory the sanitary aim of the drainage system. Above the reservoir the Elbe furnishes a purified water; but it becomes so contaminated on passing through Hamburg that within this area it cannot undergo self-purification. To be serviceable for consumption or domestic use its water should be further purified, as by filtration through sand, as is done at Altona, a few kilometers below Hamburg. At Cuxhaven the Elbe again becomes free from Hamburg impurities. It is plain also that the same degree of contamination may act differently on different soils, and all epidemics of cholera in Hamburg have shown essential differences between quarters situated upon marshy land and upon high ground.

Reincke has shown that since the introduction of a drainage system into Hamburg the frequency of typhoid fever has diminished, except for some variations in abnormally dry seasons. Epidemics of typhoid fever have this in common with cholera; but that Hamburg, in spite of its excellent drainage, may still be a fruitful soil for typhoid fever is shown by the epidemics of that disease of 1885 to 1887, while last year, associated with cholera, there was a notable increase in typhoid fever.

We are more fortunate in Munich, for formerly, with very good drinking water, but high level of subsoil water, we often had more than twenty deaths annually from typhoid fever among 10,000 inhabitants.

However, since 1881, with subsoil water at a very low level, the deaths have not exceeded one. The once notorious typhoid soil of Munich has been gradually purified by sanitation, and we regard with some confidence any fresh visitation of cholera. In Hamburg itself a system of sand filtration was commenced until the cholera intervened, but the new water works are expected to be completed in the autumn of 1893. These works, on a gigantic scale, are under the direction of Engineer-in-Chief A. Meyer, and will cost many millions of marks, but not so much as Hamburg has lost by the cholera of 1892.

The part played by water in this epidemic has been variously explained. The "drinking water theorists" think that comma bacilli from Russian Jews found their way from the Elbe to the reservoirs and were thus distributed throughout the town—a most plausible and comfortable explanation for the laity and the profession. Still experience does not always fit in with this theory, for outbreaks quite as "explosive" have occurred without the drinking water being at fault. I leave it undetermined whether in 1892 the Hamburg water operated directly as drinking water or indirectly as foul usable water. It is strange that in spite of the most careful search they should have had the misfortune not to find any comma bacilli in the Elbe water or in the water from the Hamburg mains. This is said to prove nothing, since other bacteria may be present which fluidify nutrient gelatine. Yet Koch found his bacilli in a Calcutta tank, and Fraenkel in the water of the Rhine, where lay a boat containing a case of cholera. The water of the Indian ponds is not only drunk, but used for bathing and washing. The comma bacilli escaping from the human intestine into river or pool must be overcome by other bacteria and disappear very rapidly. I am not asserting that the comma bacillus has no etiological importance, but I believe it impossible for it to be the *x* which can excite and develop cholera epidemics apart from the *y*. And if we have found a specific micro-organism in an infectious disease, we ought to hope that some means may be found thereby to combat the disease. Tuberculosis is a striking example. The discovery of the tubercle bacillus in the sputa of phthisical patients was scientifically as interesting and important as that of the comma bacillus in choleraic evacuations. But since the discovery of the tubercle bacillus, which is older than that of the comma bacillus, neither more nor fewer people have died from phthisis than formerly.

The present protective measures against cholera rest entirely on purely theoretical contagionist bases. We have become very one-sided, thinking that cholera must be met by prevailing theories and not that theory should follow after cholera. It is deemed most important to seize the comma bacillus from the first case occurring in a place, and when its presence is proved, to isolate the patient, disinfect his excreta and his dwelling, and then one thinks that the place, be it village or town, is protected from cholera. If in Hamburg the first case had been isolated and disinfected, the epidemic, so they think, could not have broken out. Until a case comes to official knowledge it is in contact with others and the evacuations are not disinfected; and when reported, it must be determined bacteriologically whether it is a case of Asiatic cholera or one of cholera nostras. Then the source of infection must be traced, and often the disease breaks out in many parts simultaneously, as it did in Hamburg, adding to the difficulty of the task. Nothing but absolute stoppage of all traffic could avail, and that would be a greater misfortune than the cholera. The spread of the cholera germ is not to be prevented, either in India or outside it, by isolation, disinfection, cordons, quarantines, etc. Just as, in spite of custom houses, goods are still smuggled over the frontier, so the bacteria and viruses will be smuggled through all our barriers. Still, improved sanitation may do much to prevent the smuggled germs gaining a foothold. In the sixties, when Prussia, Belgium, Holland and France had most severe epidemics, Great Britain was only moderately invaded, and since 1866, in spite of its colossal traffic with the motherland of cholera, and the introduction of numerous cases from other lands, England has not had a single local epidemic, neither during the cholera time on the Continent from 1871 to 1874, nor during 1884 to 1887. Even this year cholera has not invaded England from Hamburg, Russia and France, although England (London) was the only land which fearlessly trafficked with ships coming from infected ports.

If one cannot act against the introduction of the germ *x*, one must seek to act in the directions of *y* and *z*, and strive to make places or people immune. Every epidemic shows that many do not possess the *z*, the individual disposition, and that they are immune. Some are protected by their own serum, perhaps, and it may be possible to ward off cholera, like variola, by protective inoculation. The contagium of variola was not mastered by isolation and disinfection until vaccination proved successful. Cholera is not contagious like variola, but depends on local conditions, and susceptible places may be rendered immune, like Fort William in Calcutta. There have been in other places as severe epidemics as this in Hamburg, but where all these measures of isolation, etc., were not in vogue, and where the disease arose and subsided as quickly as it did at Hamburg.

[Professor von Pettenkofer here contrasts the epidemic at Munich of 1854 with the Hamburg outbreak. He goes on to contend that neither military cordons, as in Russia, nor quarantines, nor the forbidding of fairs, etc., have any influence, and fears that next year, if there is not much rain, it may spread over Germany.]

The contagionists say that when cholera breaks out in a place the rules demanded by their theory should be enforced. I am convinced that this is a mistake. I know of cases where nothing of this sort has been done and the epidemic has been remarkably mild, much milder than where the contagionist practice has been carried into effect.

[In proof of this Professor von Pettenkofer cites at some detail the outbreak of cholera in Bavaria in 1836, and shows that the authorities acted on the anti-contagionist plan, only transferring those cases to hospital which could not be cared for at home, and not interfering with public meetings and feasts. At that time Munich was in an insanitary state yet the epidemic was the mildest of the three it has experienced. There was no dread of cholera in those days which he remembers in his youth. Nothing was known of bacteria, and cholera was attributed not to comma bacilli, but to the genus epidemicus. Traffic in and out of Munich was not deranged.]

He concludes by expressing the hope that the recent appearance of cholera in Europe will lead to a restriction of regulations based on merely theoretical grounds, so greatly hampering free intercourse and even contrary to humanity, without any practical effect, and that the money expended on them will be devoted to attainable sanitary aims. Reflecting how many millions must have been thus sacrificed to theory in a single town like Hamburg, it is inconceivable, he says, "how opposition can be made to the new military bill before the Reichstag, which is based on much sounder grounds than the contagionist rules against cholera. I live and die in the conviction that our army will subdue enemies who would invade us from the east or the west, but not that our capture of bacilli, our cholera barracks, isolations, disinfections, prohibitions of entry and transit, or our quarantines can prevent the invasion and the dissemination of cholera."

PROF. THE REV. CHARLES PRITCHARD, D.D.

AT the recent anniversary meeting of the Royal Society, at Burlington House, Professor Pritchard, D.D., was awarded the Royal Society's gold medal for his work on Photometry and Stellar Parallax at the University Observatory, Oxford. The venerable professor, who is eighty-three years of age, was present to receive in person the recognition of his labors as one of the great pioneers of modern astronomy. Professor Pritchard graduated fourth wrangler in 1830. He was elected a fellow of St. John's College. The learned professor, who is widely known as a scientific author of very high attainments, is a fellow of the Royal Society. It was

PROFESSOR THE REV. CHARLES PRITCHARD, D.D.

at his instance that the University of Oxford erected an observatory with all appliances for instruction and research.

BLACK CURRANTS.

WHEN well grown, the black currant is not only one of the most useful of fruits, but also one of the most remunerative. Of late years some growers have had a serious evil to contend with, viz., the currant bud mite. Bushes or buds affected are easily noticed in the early spring, the buds having a rounded or swollen appearance instead of bursting out into leaf. The remedy for this is either to pick off the swollen buds and burn them or cut off the affected shoots. Syringing the bushes in the autumn with some insecticide is also resorted to as a safeguard. Happily, however, this pest is only local, so that it is within the grower's power to stamp it out. The black currant will succeed well on almost any soil and situation; it has also its likes and dislikes in this respect. For instance, in the west of England it may be seen thriving to perfection in the valleys of the Severn and the Teme. I have often been struck with the growth there made, the annual shoots from the bottom partaking more of the character of willows. The above proves that the black currant is a gross feeder, and where it does fail it must be for the want of adequate support or faulty pruning. The worst soil to contend with is a stiff clay, but even on this the bushes will succeed well if attended to as regards rich top dressings.

As regards pruning, all that is necessary is to thin out any old bearing wood to allow room for the younger, which should be encouraged to grow right from the bottom. In the case of the black currant, all the lower buds are retained when the cutting is made, so that the future bush will partake of the character of what is termed a "stool." To produce a good stool, the bushes after planting should be cut down to within two inches or three inches of the ground level. I have renovated old bushes by completely cutting them down to within a few inches of the ground line, and with the assistance of a good dressing of manure and burned garden refuse the after-growth has been remarkably strong. The burned refuse and manure form good material for top dressing, which is very important, merely laying it on the surface to the depth of two inches, not forking it in the least. It is not often that time can be afforded to apply a soaking of liquid manure or sewage, but where it can be given, there cannot be any question as to its value. I have often been struck with the heavy crops of fruit sometimes seen in cottage gardens where the bushes are growing on the brink of a brook or ditch. Where there is a choice of position, that which is low and moist and partially shaded is the best. The varieties of black currants are not many, Lee's Prolific being, perhaps, the best of any. Carter's Black Champion is also good, it also having the merit of not dropping so quickly after being fully ripe. Black Naples is also a good variety.—*Y. A. H., in The Garden.*

RULES FOR THE SPELLING AND PRONUNCIATION OF CHEMICAL TERMS.

ADOPTED BY THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE IN 1891.

IN 1887 a committee was appointed by the American Association for the Advancement of Science, to consider the question of attaining uniformity in the spelling and pronunciation of chemical terms. The work of this committee extended through the following four years. As a result of widespread correspondence and detailed discussion at the annual meetings of the Chemical Section of the American Association, the accompanying rules have been formulated and adopted by the association. They are submitted to chemists generally, and especially to the large number of those engaged in teaching chemistry, with the request that a cordial and earnest effort be made to render their use general, and thus obviate the many difficulties arising from the present diversities of style.

The following summary of the rules has been arranged in the form of a chart for general distribution to high schools and colleges, so that they may be kept permanently and prominently before the eyes of teachers and pupils.

T. H. NORTON, Ph.D.,
Professor of Chemistry,
University of Cincinnati.

EDWARD HART, Ph.D.,
Professor of Chemistry,
Lafayette College,
Easton, Pa.

H. CARRINGTON BOLTON, Ph.D.,
University Club,
New York City.

JAS. LEWIS HOWE, Ph.D., M.D.,
Polytechnic Society,
Louisville, Ky.

} *Committee.*

GENERAL PRINCIPLES OF PRONUNCIATION.

1. The pronunciation is as much in accord with the analogy of the English language as possible.
2. Derivatives retain as far as possible the accent and pronunciation of the root word.
3. Distinctly chemical compound words retain the accent and pronunciation of each portion.
4. Similarly sounding endings for dissimilar compounds are avoided (hence **-id, -ite**).

ACCENT.

In polysyllabic chemical words the accent is generally on the antepenult; in words where the vowel of the penult is followed by two consonants, and in all words ending in **-ic,** the accent is on the penult.

PREFIXES.

All prefixes in strictly chemical words are regarded as parts of compound words, and retain their own pronunciation unchanged (as ā′ceto-, ā′mĭdo-, ă′zo-, hȳ′dro-, ī′so-, nĭ′tro-, nĭtrō′so-).

ELEMENTS.

In words ending in **-ium,** the vowel of the antepenult is short if **i** (as ĭrĭ′dium), or **y** (as dĭdȳ′mium), or if before two consonants (as cā′leium), but long otherwise (as tĭtā′nium sēlē′nium, chrō′mium).

alū′minum	mōlȳ′bdenum
a′ntimony	nĭ′ckel
a′rsĕnic	nĭ′trogen
bā′rium	ŏ′smium
bĭ′smuth (biz)	ŏ′xygen
bō′ron	pallā′dium
brō′mĭn	phŏs′phorus
cā′dmium	plā′tinum
cā′leium	potā′ssium
ca′rbon	rhō′dium
cē′rium	rubĭ′dium
cē′sium	ruthē′nium
chlō′rĭn	samā′rium
chrō′mium	sca′ndium
cō′balt	sēlē′nium
colū′mbium	sĭ′licon
co′pper	silver
dĭdȳ′mium	sō′dium
e′rbium	strō′ntium (shium)
flū′orĭn	sū′lfur
gā′llium	tā′ntalum
germā′nium	tellū′rium
glū′cinum	te′rbium
gold	thā′llium
hȳ′drogen	thō′rium
ĭ′ndium	tin
ĭ′odĭn	tĭtā′nium
ĭrĭ′dium	tū′ngsten
iron	ūrā′nium
lā′nthanum	vănā′dium
lead	ytte′rbium
lĭ′thium	ȳ′ttrium
magnē′sium (zhium)	zinc
ma′nganese (eze)	zirco′nium
me′rcury	

Also: ămmō′nium, phosphō′nium, hă′logen, cȳā′nogen, ămĭ′dogen.

Note in the above list the spelling of the halogens, cesium, and sulfur; **f** is used in the place of **ph** in all derivatives of sulfur (as sulfuric, sulfite, sulfo-, etc.)

TERMINATIONS IN -ic.

The vowel of the penult in polysyllables is short (as cȳā′nic, fūmā′ric, arsē′nic, sĭlĭ′cic, Iō′dic, būtȳ′ric), except (1) **n** when not used before two consonants (as mercū′ric, prū′ssic), and (2) when the penult ends in a vowel (as benzō′ic, olē′ic); in dissyllables it is long except before two consonants (as bō′ric, cĭ′tric). Exception: acē′tic or acē′tic.

The termination **-ic** is used for metals only where necessary to contrast with **-ous** (thus avoid aluminic, ammonic, etc.)

TERMINATIONS IN **-ous.**

The accent follows the general rule (as plā′tinous, sū′lfurous, phŏ′sphorous, coba′ltous). Exception: acĕ′tous.

TERMINATIONS IN **-ate** AND **-ite.**

The accent follows the general rule (as ā′cetāte, vā′nadāte). In the following words the accent is thrown back: ă′bietāte, ă′lcoholāte, ă′cetonāte, ă′ntimonīte.

TERMINATIONS IN **-id** (FORMERLY **-ide**).

The final **e** is dropped in every case and the syllable pronounced **id** (as chlō′rĭd, ĭ′odĭd, hȳ′drĭd, ŏ′xĭd, hydrŏ′xĭd, sū′lfĭd, ă′mĭd, ă′nillĭd, mūrĕ′xĭd).

TERMINATIONS IN **-ane, -ene, -ine** AND **-one.**

The vowel of these syllables is invariably long (as mĕ′thāne, ĕ′thāne, na′phthalēne; a′nthracēne, prŏ′pine, quĭ′nōne, ă′cetōne, kĕ′tōne).

A few dissyllables have no distinct accent (as benzēne, xȳlēne, cētēne).

The termination **-ine** is used only in the case of doubly unsaturated hydrocarbons, according to Hofmann's grouping (as propine).

TERMINATIONS IN **-in.**

In names of chemical elements and compounds of this class, which includes all those formerly ending in **-ine** (except doubly unsaturated hydrocarbons) the final **e** is dropped, and the syllable pronounced **-in** (as chlō′rĭn, brŏ′mĭn, etc., ă′mĭn, ă′nillĭn, mo′rphĭn, quĭ′nĭn (kwĭ′nĭn), vanĭ′llĭn, alloxă′ntĭn, absĭ′nthĭn, emū′lsĭn, că′ffeĭn, cŏ′caĭn).

TERMINATIONS IN **-ol.**

This termination, in the case of specific chemical compounds, is used *exclusively* for alcohols, and when so used is never followed by a final **e.** The last syllable is pronounced **-ōl** (as glȳ′cōl, phĕ′nōl, crĕ′sōl, thȳ′mōl (tl), glȳ′cerol, quĭ′nōl. Exceptions: ălcohŏl, a′rgōl.

TERMINATIONS IN **-ole.**

This termination is always pronounced **-ōle,** and its use is limited to compounds which are not alcohols (as ĭ′ndōle).

TERMINATIONS IN **-yl.**

No final **e** is used; the syllable is pronounced **yl** (as ă′cetȳl, ă′mȳl, cĕ′rotȳl, cĕ′tȳl, ĕ′thȳl).

TERMINATIONS IN **-yde.**

The **y** is long (as ă′ldehȳde).

TERMINATIONS IN **-meter.**

The accent follows the general rule (as hydrŏ′meter, barŏ′meter, lactŏ′meter). Exception: words of this class used in the metric system are regarded as compound words, and each portion retains its own accent (as cĕ′ntime″ter, mĭ′llime″ter, kĭ′lome″ter).

MISCELLANEOUS WORDS

which do not fall under the preceding rules.

Note the spelling: albumen, albuminous, albuminiferous, asbestos, gramme, radical.

Note the pronunciation: a′lkalīne, a′lloy (n. & v.), a″llotropy, a″llotropism, ĭ′somerism, pŏ′lymerism, apparā′tus (sing. & plu.), āqua regia, barȳ′ta, cĕntigrade, co′ncentrated, crystallīn or crystallīne, electrŏ′lysis, lī′ter, mŏ′lecule, mŏlĕ′cular, nŏ′menclā″ture, olĕ′fiant, vā′lence, ū′nivā″lent, bĭvā″lent, trĭvā″lent, quadrivā″lent, tĭ′trate.

A LIST OF WORDS WHOSE USE SHOULD BE AVOIDED IN FAVOR OF THE ACCOMPANYING SYNONYMS.

For—	*Use—*
sodic, calcic, zincic, nickelic, etc., chlorid, etc.	sodium, calcium, zinc, nickel, etc., chlorid, etc. (vid. terminations in **-ic** supra).
arsenetted hydrogen	arsin
antimonetted hydrogen	stibin
phosphoretted hydrogen	phosphin
sulfuretted hydrogen, etc.	hydrogen sulfid, etc.
beryllium	glucinum
niobium	columbium
glycerin	glycerol
hydroquinone (and hydrochinon)	quinol
pyrocatechin	catechol
resorcin, etc	resorcinol, etc.
mannite	mannitol
dulcite, etc.	dulcitol, etc.
benzol	benzene
toluol, etc.	toluene, etc.
thein	caffein
furfurol	furfuraldehyde
fucusol	fucusaldehyde
anisol	methyl phenate
phenetol	ethyl phenate
anethol	methyl allylphenol
alkylogens	alkyl haloids
titer (n.)	strength or standard
titer (v.)	titrate
monovalent	univalent
divalent, etc.	bivalent, etc.
quantivalence	valence

Fāte, făt, fär, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mōve, tūbe, tŭb, rūle, mȳ, ȳ=I.

′ Primary accent; ″ secondary accent.

N. B.—The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

DIFFUSION OF GASES.

By ALEXANDER JOHNSTONE.

As illustrating a lecture on oxygen or air, a strong solution of pyrogallic acid in KHO or NaHO is often exposed to the gas or the atmosphere to show its great power of absorbing free oxygen, and its instant change of color when exposed to it. This experiment "tells better" if a clear *colorless* solution of alkaline pyrogallol be shown to the class before exposure to oxygen. This can be done very easily and quickly. Into a rather deep test glass, such as is ordinarily used in lecture experiments, place some solid pyrogallic acid and then a little water, just enough to barely dissolve it. Next put a small handful of sodium carbonate into a flask and cover with HCl to drive the CO_2 off. Pour the CO_2 gas into the glass above the pyrogallol, and then add the KHO to the latter. The class will see that the alkaline solution below the CO_2 remains colorless. To show the change caused by the presence of O, pass the latter from a tube into the lower stratum of the CO_2 covering, or incline the glass so as to throw out the CO_2 and admit the air. The change will be instantaneous.

This experiment should also be of service in making evident to the eye the diffusion of gases—the heavier CO_2 slowly mixing upward with the air and the latter downward with the CO_2, as evinced by the assumption of color by the pyrogallate and the gradual deepening of the coloration as the diffusion progresses.—*Chem. News.*

THE SCIENTIFIC AMERICAN

Architects and Builders Edition

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture,** richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilationa and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

MUNN & CO., Publishers,
361 Broadway, New York.

THE SCIENTIFIC AMERICAN

Cyclopedia of Receipts,

NOTES AND QUERIES.

680 PAGES. PRICE $5.

This splendid work contains a careful compilation of the most useful Receipts and Replies given in the Notes and Queries of correspondents as published in the SCIENTIFIC AMERICAN during nearly half a century past; together with many valuable and important additions.

Over Twelve Thousand selected receipts are here collected; nearly every branch of the useful arts being represented. It is by far the most comprehensive volume of the kind ever placed before the public.

The work may be regarded as the product of the studies and practical experience of the ablest chemists and workers in all parts of the world; the information given being of the highest value, arranged and condensed in concise form, convenient for ready use.

Almost every inquiry that can be thought of, relating to formulæ used in the various manufacturing industries, will here be found answered.

Instructions for working many different processes in the arts are given. How to make and prepare many different articles and goods are set forth.

Those who are engaged in any branch of industry probably will find in this book much that is of practical value in their respective callings.

Those who are in search of independent business or employment, relating to the manufacture and sale of useful articles, will find in it hundreds of most excellent suggestions.

MUNN & CO., Publishers,
361 Broadway, New York.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. BIOGRAPHY.—Prof. the Rev. Charles Pritchard, D.D.—Note on the life of one of the great pioneers of astronomy.—With portrait.—1 illustration ... 1426

II. CHEMISTRY.—Diffusion of Gases.—By ALEXANDER JOHNSTONE.—A simple experiment illustrating the action of oxygen on alkaline pyrogallate and incidentally the diffusion of gases ... 1426
Rules for the Spelling and Pronunciation of Chemical Terms.—An official statement by the American Association upon this important subject, with full list of examples ... 1426

III. ELECTRICITY.—Improved Electric Forge.—A forge for heating sheets of metal from which shovels and similar articles are to be made.—7 illustrations ... 1426
Present and Future Developments of Electricity.—By Dr. W. W. JACQUES.—A popular presentation of the theory of electrical action.—The electric current.—The present condition and future aspects of the science ... 1426
The Electrical Uses of Mica.—By CHARLES W. JEFFERSON and ARTHUR H. S. DYER.—Mica in armatures and commutators.—Its different varieties.—Its treatment and sizes obtainable.—A very interesting and valuable paper ... 1426
The Inventor of the Lightning Rod.—By JOSEPH J. KRAL.—An interesting note on the ancient history of electricity.—3 illustrations ... 1427
Water Electricity.—The production of electricity by the impact of drops of water ... 1426
What are Lines of Force?—Interesting note on lines of force and their place in electrical science ... 1426

IV. FRUIT CULTURE.—Black Currants.—Value of this fruit in the commercial sense and the proper methods of cultivation ... 1426

V. MECHANICAL ENGINEERING.—Centrifugal Force as Applied to Revolving Machinery.—By G. D. HISCOX.—A valuable paper on the strains to which emery wheels, grindstones, centrifugal pumps, and similar machinery is subjected, with tables.—4 illustrations ... 1426
Improved Steel Casting Ladle.—A casting ladle for use for Siemens steel works.—Design adapted for ten to forty tons capacity.—1 illustration ... 1426
Large Steam Cylinders and their Liners.—The modern construction of large steam cylinders.—The attachment of the linings.—4 illustrations ... 1426

VI. MEDICINE AND HYGIENE.—On Cholera, with Reference to the Recent Epidemic at Hamburg.—By Privy Councilor VON PETTENKOFER.—An exhaustive paper on the subject of cholera, with experiments on the bacilli.—The personal experiences of the author in the drinking of a solution containing bacilli ... 1426

VII. MISCELLANEOUS.—Life Saving Device for Wells.—A life-preserver for preventing a class of suicides which is of very frequent occurrence in India.—2 illustrations ... 1426
The Canary Islands.—Notes on the temperature of the Canary Islands.—Their geographical features and other items of interest ... 1426
The Mahomedan Buckra Eide Festival.—A Mahomedan festival, as celebrated in India by over 1,000 participants.—2 illustrations ... 1426
The World's Fair.—Rules governing the supply of lighting powers to exhibitors in the department of electricity ... 1426

VIII. NAVAL ENGINEERING.—The Austrian Ram-Cruiser Kaiserin Elisabeth.—The fourth great war ship of the Austrian navy.—Details of her construction.—1 illustration ... 1426

IX. RAILWAY ENGINEERING.—Great Northern Railway Locomotive.—Interesting examples of English railway practice.—A yard traveling crane and an express locomotive.—2 illustrations ... 1426

X. TECHNOLOGY.—Cost of Preparing Caustic and Bleach by the Electrolysis of Salt.—*Resume* of the cost of carrying on the new electric bleaching process ... 1426
Japanese Camphor.—Valuable *resume* of the statistics of camphor, and also of the mode of collecting it ... 1426
The Manufacture of Liquors and Preserves.—By J. DE BRAVANS.—Continuation of this treatise, opening the subject of the preparation of liquors by distillation.—3 illustrations ... 1426

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of authors. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address

MUNN & CO., 361 Broadway, New York.

PATENTS!

MESSRS. MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had *forty-five years' experience,* and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. Munn & Co. also attend to the preparation of Caveats, Copyrights for Books, Labels, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge, on application, containing full information about Patents and how to procure them; directions concerning Labels, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases, Hints on the Sale of Patents, etc.

We also send, *free of charge,* a Synopsis of Foreign Patent Laws, showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York.

BRANCH OFFICES.—No. 622 and 624 F Street, Pacific Building, near 7th Street, Washington, D. C.